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# AN ENVIRONMENT AT RISK

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## *The First Annual Report on The State of the Massachusetts Environment*



EXECUTIVE OFFICE  
OF ENVIRONMENTAL  
A F F A I R S

Michael S. Dukakis  
Governor

John P. DeVillars  
Secretary



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The State of the Massachusetts Environment**

**COMMONWEALTH OF MASSACHUSETTS  
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS**

John P. DeVillars  
Secretary

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Governor

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THE COMMONWEALTH OF MASSACHUSETTS  
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS

MICHAEL S. DUKAKIS  
GOVERNOR

JOHN DeVILLARS  
SECRETARY

April 22, 1990

Dear Citizens of Massachusetts:

I am pleased to present the first annual Massachusetts State of the Environment Report. This report, the culmination of months of effort within the Commonwealth's environmental agencies, is the first of what I hope will be a series of careful examinations of our state's environmental health.

Last year, the Special Commission on Environmental Operations, chaired by former Senator Paul Tsongas, recommended that EOEa prepare an annual report such as this one. I believe that this document, and those that follow, will prove to be as useful as the Tsongas Commission anticipated.

**Our examination reveals an environment at risk.** Few pages of this report are without warnings, based on data and trends, of significant harms that threaten Massachusetts' air, water, land, and wildlife. The report also points out areas where we need to obtain more information to guide our future decisions.

Not all of the news is disturbing. Massachusetts has made progress in some areas, including lower levels of certain air pollutants, improved surface water quality, and significant successes in bringing back animal species we feared had left for good. Much of the credit for this progress must go to Governor Michael Dukakis and the Massachusetts legislature. Over the past decade and a half, thanks to their leadership, this state has set an admirable standard for environmental protection.

However, as the last chapter of the report indicates, **there is much work left to do.** The problems that remain, from choking smog and leaking landfills to contaminated shellfish beds and vanishing wildlife habitat, will take all of our energy and creativity to solve. We cannot afford to rest on past accomplishments. We must continue to firmly enforce our laws and stretch our financial resources as far as possible.

Finally, I want to recognize the work of the dedicated professionals in our state's environmental agencies. They are our environment's first line of defense, and they do a splendid job. This report is dedicated to them.

Sincerely,

A handwritten signature in dark ink, appearing to read "John DeVillars", with a long, sweeping horizontal stroke extending to the right.

John DeVillars



# **AN ENVIRONMENT AT RISK**

## **The First Annual Report on The State of the Massachusetts Environment**

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**This report is dedicated to the more than 3,500 employees of the Massachusetts Environmental Affairs Secretariat. They serve the Commonwealth with great energy, commitment, and enthusiasm. Our environment is cleaner, more enjoyable, and more beautiful because of their work.**

## ACKNOWLEDGEMENTS

The Executive Office of Environmental Affairs wishes to thank the many individuals who contributed to the writing, review and production of this State of the Environment Report. Numerous EOEA and environmental agency staff committed time and energy far above and beyond the call of duty. EOEA is grateful for that dedication and commitment which exemplifies the dedication which they bring on a daily basis to their work for the Commonwealth.

Thanks are also due to the external reviewers who took time from their busy schedules to read this report and offer many excellent suggestions and comments. This group includes Rita Barron, Gary Clayton, Rich Delaney, Joseph Larson, Douglas McDonald, Peter Shelley and Judy Shope.

Ken Hagg and Bob O'Keefe at DEP lent their valuable support at points crucial to completion of this report. Professors Jack Tager and Richard Wilkie of the University of Massachusetts provided a manuscript of their *Historical Atlas of Massachusetts* which will soon be published by the University of Massachusetts Press.



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**EXECUTIVE SUMMARY**

**THE FIRST ANNUAL REPORT ON  
THE STATE OF  
THE MASSACHUSETTS ENVIRONMENT**

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**An Environment at Risk**

The Massachusetts environment is at risk. Its future health is in our hands.

Our environment is the product of untold years of natural forces and relatively recent human interaction with them. When the last ice age ended 12,000 years ago, it set the stage for plants and animals to develop and to form the integrated natural communities we know as ecosystems. It uncovered land that, left alone, tended to become forest, except in the places where water came to dominate. Rivers and streams carved their paths, lakes and ponds and wetlands formed, and the ocean sculpted the shoreline and created the unique character of the coastal region.

Our Native American forebears lived in harmony with this world; it was the European settlers who began to change it. Since their arrival Massachusetts has been, in turn, home to an agrarian society that cleared the forests for farms, an urban, industrial economy that harnessed the power of the rivers to run its mills and factories, and a densely (though unevenly) populated state hosting a population whose commerce increasingly centers around information and services.

The transformation of our state's land and population has resulted in a complex balance sheet of costs and benefits. The motive for much of our settlement and development activity has been to improve the standard of living of our people. In economic terms this effort

has largely been a success. But in the last two decades, a very small fraction of Massachusetts' history, we have come to see the environmental costs of this transformation. We have also come to realize that many of the economic benefits may themselves be short lived and not sustainable.

**An Assessment of Environmental Quality**

One cannot accurately describe the state of our environment with a well chosen adjective or two, for it is many different things. Depending on where and how closely one looks, it is pristine or contaminated, productive or barren, teeming with life or inhospitable to living things, fragile or resilient, beautiful or ugly, safe or unsafe.

Efforts over the past twenty years to protect and improve environmental quality have met with some success. Some threats to environmental quality have been contained, and programs currently in place are expected to result in measurable improvements over time. Other problems are just now being recognized and addressed. In many areas, our knowledge about environmental threats and impacts and the efficacy of various responses is too limited. The effectiveness of some of our environmental protection efforts will not be measurable for years to come. But we can make some judgments about the health of and threats to our resources, judgments that we can act on today and refine and improve in the years ahead.

## Air

Attempts to improve the quality of our air over the past decade have in many respects proven successful. Emissions of each of the four major types of pollutants monitored by the Commonwealth have decreased during this period. As a result Massachusetts is in compliance with four of six National Ambient Air Quality Standards. On the other hand, even though exceedences of both the ozone and carbon monoxide standards have decreased, Massachusetts has yet to achieve compliance for these air pollutants. The major difficulty in reaching compliance with those standards continues to be emissions from mobile sources, primarily automobiles.

Air pollutants fall into two main categories, combustion emissions and evaporative emissions. The burning of oil and coal releases particulates and gases, such as carbon monoxide, sulfur dioxide, and nitrogen oxides. Evaporative emissions are releases of volatile organic compounds (VOCs) during various industrial processes, refueling of combustion engines, and many household activities.

There are 5,500 stationary sources of **air pollution** in the Commonwealth, some of which emit hundreds of tons of pollutants each week. The seven largest electric utility plants in Massachusetts emit from 24 million to 160 million pounds of sulfur dioxide each year. There are 3.5 million automobiles in the Commonwealth which in 1985 traveled 105,270,500 miles on Massachusetts roads and consumed 2.4 billion gallons of gasoline.

The number of days for which the **ozone** standard was exceeded have generally declined over the past ten years, except for 1983 and 1988, when warm

temperatures resulted in higher ozone concentrations. Exceedences of the carbon monoxide standard have shown significant decreases as well since a high of 29 in 1981. From 1980 to 1987 all four major emission categories have shown encouraging decreases. VOC emissions decreased by 44 percent, carbon monoxide by 33 percent, nitrogen oxides by 7 percent, and sulfur dioxide by 8 percent.

**Acid deposition** is a specific air pollution problem caused by emissions of sulfur dioxide, nitrogen oxides, and VOCs, many of which arrive in Massachusetts from out of state sources. Acid deposition results in 16.2 to 27.5 pounds of sulfate and 8 to 22 pounds of nitrate falling each year on every acre in Massachusetts. The average annual acidity of precipitation in Massachusetts is approximately six times greater than uncontaminated precipitation.

The result of this acid deposition is that the acid neutralizing capacity (ANC) of our environment has been exhausted in many locations. It has been shown that 64 percent of the Commonwealth's surface water is vulnerable to acid deposition. Over 185 lakes, ponds and streams are known to be acidified. Loss of fish and other aquatic organisms is occurring throughout the Commonwealth as pH, the measure of acidity, declines.

A relatively recent, and potentially very serious, concern resulting from certain air pollutants is **global climate change**. Global climate change is a phenomenon that is thought to occur when the earth's heat is trapped by certain gases in the atmosphere rather than radiating back into space. These so called greenhouse gases are carbon dioxide, methane, chlorofluorocarbons (CFCs), and nitrogen oxides. CFCs have also been implicated in the disintegration of the Earth's

protective layer of ozone in the upper atmosphere.

Changes in climate and sea level may result if the accumulation of global warming gases is not abated. Estimates of possible sea level rise by Environmental Protection Agency of six to eight feet in the next 100 years would bring devastation to the Massachusetts coast. A one foot sea level rise would put Boston's Long Wharf and significant portions of Logan Airport under water.

The National Academy of Sciences projects a 75 percent chance of carbon dioxide doubling by 2100 with a potential rise in average global temperature of 1.5 to 4.5 degrees F.

## Water

Surface water quality has improved with regard to conventional pollutants (oxygen-demanding substances, suspended solids, and bacteria) over the past two decades. According to the most recent assessment of the water quality of the Commonwealth's rivers and streams, 43 percent meet established standards, 37 percent partially meet designated classifications, and 20 percent do not meet their designated classifications.

In 1972, when the federal Clean Water Act was enacted, only 16 percent of the Commonwealth's rivers and streams met the "fishable, swimmable" standards; today it is close to 50 percent. The construction of wastewater treatment plants is chiefly responsible for this improvement.

Of 999 river miles assessed for toxics, 264 (26.4 percent) river miles showed at least traces of contamination.

It appears that eutrophication, which results from excess nutrients due to waste water and runoff, is an increasing problem, especially for lakes and ponds. One hundred thirty-six of 478 lakes and ponds assessed for a 1987 report to EPA were listed as threatened or impaired by eutrophication.

Acidification of surface waters remains a major concern as well. Sixty-four percent of the Commonwealth's surface waters is at significant risk of becoming further acidified if acid deposition is not reduced. There is no overall trend in acid deposition in Massachusetts from 1982 through 1987. There are no detectable trends in alkalinity and pH of surface waters.

The overall condition of our **groundwater** resources is uncertain, based upon the data available in this report. Since all public water supplies are tested frequently for a significant range of pollutants, the data that could be used for a more comprehensive analysis of trends and conditions do exist; such an analysis should be undertaken in the future.

Seventy-four public water supplies have been closed due to contamination during the past 12 years. It is known that 636 private wells in 120 communities have also been contaminated. The number of cases in which those standards are exceeded appears to be on the rise, and the risks to groundwater posed by underground storage tanks and releases of hazardous materials is substantial. There are an estimated 50,000 underground storage tanks in Massachusetts and as many as 20 percent of them may leak each year.

Two pesticides, ethylene dibromide (EDB) and aldicarb, have contaminated over 50 private wells and resulted in the closing of West Springfield's municipal

water supply. Six other pesticides used in Massachusetts are being monitored for potential effects on groundwater.

**Wastewater** is the effluent of industrial treatment plants, sewage treatment plants, and private septic systems. The 139 publicly owned treatment plants in Massachusetts together treat over one billion gallons of sanitary and industrial wastewater each day. There are over 650,000 individual septic systems.

Wastewater can result in pollution of surface waters by pathogens, toxics, and nutrients. Pathogens, often referred to as conventional pollutants, make water unsafe for consumption and in coastal waters result in the closure of swimming beaches and shellfish beds. Excess nutrients result in eutrophication of both fresh and marine waters, making them unsuitable for many purposes. Toxics, released primarily in industrial wastewaters and by combined sewer overflows, include heavy metals, hydrocarbons, and PCBs. These become available for uptake by aquatic organisms and enter the food chain causing potential health problems in susceptible elements of the population.

## Coastal Resources

While there are obvious **marine water quality** problems caused by both point and non-point pollutants, the information available for inclusion in this report presents a very incomplete picture of marine water quality along our shores. There is significant evidence of increased eutrophication of near-shore environments. And even though the National Pollutant Discharge Elimination System (NPDES) regulates the discharge of pollutants into rivers and streams so that water quality standards are not exceeded, many toxic substances continue to be deposited in the

sediments of our bays and estuaries. However, no valid trend analysis is possible based upon the intermittent data available.

**Shellfish** bed closures statewide have increased by 25.6 percent over the past decade, resulting in a total 95,642 acres being closed at an estimated annual loss of \$94.5 million. It is unclear, however, how much of this increase is due to increased monitoring and how much to increased pollution.

The most recent assessment of **estuarine water quality** by the Massachusetts Department of Environmental Protection (DEP) indicated that 41 percent of the areas monitored for toxics were affected, and that, of 170 square miles monitored, 62 percent were affected by conventional pollutants and 10 percent by excess nutrients.

Toxic loadings into **Boston Harbor** from a combination of direct industrial discharges, power plants, publicly owned wastewater treatment plants, and combined sewer overflows total over 395 tons per year of heavy metals and pesticides and over 22,880 tons per year of petrochemical hydrocarbons.

There are some data to indicate that heavy metal concentrations (lead, mercury, and cadmium) in Boston Harbor sediments have declined since 1970, but these data must be viewed as inconclusive.

Landings of cod, haddock, and yellowtail flounder have declined dramatically from a 1980 high of over 220 million pounds to less than 100 million pounds in 1987. This is primarily the result of **overfishing** exacerbated by the 1984 World Court decision that placed thousands of square miles of Georges Bank off limits to Massachusetts fishermen.

## Land and Growth

Population growth in Massachusetts since 1950 has been at less than one percent per year, yet the rate at which land is being developed for residential, commercial, and industrial purposes is much higher. The rate at which residential land use has grown since 1950 is over ten and one half times the rate of population growth. Suburban growth increases the demand for roads, which increases run-off and associated pollution. It also increases the demand for private autos, which contribute to air pollution. Residential development along the coast and the shores of lakes, ponds, and streams contributes to nutrient and pollution loading.

Rapid and inadequately planned growth is placing all of our natural resources at risk - our wetlands, groundwater, surface water, wildlife habitat, natural ecosystems, and coastal resources. Both the state and local communities have been unprepared to deal with such rapid change. Responsible growth requires that we anticipate and mitigate undesirable consequences.

The building boom of the past decade has placed **wetlands** at significant additional risk. It has recently been estimated on the basis of soil surveys that Massachusetts may have lost 42 percent of its original freshwater wetlands resource. A 1978 study by the U.S. Soil Conservation Service reported that Massachusetts loses .4 percent of its wetlands each year. A 1988 study in southeastern Massachusetts estimated wetlands loss at .2 percent per year between 1977 and 1986. Wetlands perform many vital natural functions, and further loss is unacceptable.

There are approximately 1.1 million acres of protected **open space** in the Commonwealth, an amount roughly equal to 21 percent of total land area. In the past decade, however, three acres have been developed for each acre preserved as open space.

The demand for residential land is exacerbated by many of the control measures we have endeavored to use, such as large lot zoning, which can promote rapid loss of all developable land.

Between 1951 and 1971, 365,910 acres of agricultural land in Massachusetts was converted to residential, commercial, and industrial uses; 34.7 percent of the agricultural land resource was lost in this 20 year period. If the rate at which agricultural land is being converted to other purposes does not change, all agricultural lands would be lost within the next 34 years.

On Cape Cod, during the period from 1951 to 1984, 26.2 percent of a delicate forest ecosystem was converted to residential use, an area representing 17.3 percent of the entire land mass of Cape Cod. From 1971 to 1984 alone, an area of forest land roughly equal to the size of Chatham or Harwich was developed for residential use.

There is uncertainty concerning the overall health of the Commonwealth's **forests**. Some species exhibit symptoms of decline. Acid deposition and related air pollutants are suspected agents of this decline, but the research findings are still inconclusive. Ozone is known to negatively affect many plant species at levels considerably below those known to cause effects in humans. Harmful infestations of trees by insects and diseases are primarily cyclical, but additional tree mortality can

occur when they act in combination with stresses caused by climate and air pollution.

A complete aerial survey of Massachusetts forests in 1984-85 showed 24,287 acres exhibiting symptoms of stress and decline ranging from leaf discoloration to branch dieback and dead trees.

A 1987 ground survey of some 440 sugar maple trees at 22 sites throughout western Massachusetts found that only 24 percent were in relatively good health; 60 percent in relatively poor health. Subsequent studies have shown that red spruce, norway spruce, and sugar maple are experiencing significant declines in certain areas of the Commonwealth.

### **Wildlife and Biological Diversity**

A high percentage of our native plants and animals are listed as **endangered species**, or as threatened or of special concern, and they are afforded little legal protection under existing statutes. Among non-game wildlife species in Massachusetts 8 of 82 fishes, 8 of 23 amphibians, 14 of 29 reptiles, 30 of 203 breeding birds, and 12 of 54 mammals are listed as endangered, threatened, or of special concern.

The situation concerning plant and animal species in Massachusetts has both positive and negative aspects. Certain of our recent successes in reintroducing once-native animal species are well publicized. The bald eagle, peregrine falcon, Atlantic salmon, and wild turkey have all re-established breeding populations. Other successes in wildlife management include the beaver, fisher (a large weasel), black bear, redbelly turtle, and American shad. Yet, loss of habitat due to development for residential, commercial, and industrial purposes is a serious concern and could

well reverse many recent gains.

### **Waste Management**

This past year the Commonwealth generated approximately 10 million tons of **solid waste**, 66 percent of which is municipal solid waste comprised of paper, metals, glass, food wastes, plastics, and leaf and yard waste. The remaining 34 percent includes industrial wastes, sludge, demolition and construction debris, used appliances, tires, and other wastes which require special disposal. The cost of solid waste disposal is increasing rapidly.

In 1989 Massachusetts landfilled 63 percent of its solid waste compared to a national average of 80 percent. Of the 194 active landfills in the state only 28 are constructed with liners. One hundred fifty-one of these older sites are expected to be closed by 1992.

Both landfilling and incineration of solid waste present environmental problems. New Integrated Solid Waste Management (ISWM) plans seek to minimize these problems by relying on a hierarchy of disposal options beginning with waste reduction, recycling, reuse (including composting), combustion, and landfilling as a last resort.

It is estimated that in 1987 over 250,000 tons of **hazardous waste**, including the byproducts of industrial processes, the service sector, and households, were generated in Massachusetts. There are over 13,000 registered generators of hazardous waste in the state of which 1,573 are large-quantity generators, producing more than 1,000 kilograms per month; 9,154 small-quantity generators (100-1,000 kilograms per month) and 3,109 very small generators (0-100 kilograms) account for the rest of the waste stream.

There are 27 facilities in Massachusetts registered to store, recycle, or treat hazardous waste. All disposal of hazardous waste is currently done at out of state facilities.

One legacy of the past is the 3,377 **hazardous waste sites**, spills, and locations that by October 1989 had received some type of action by the state's Department of Environmental Protection. Remedial action has been completed at 271 sites. At 1,278 sites releases have been confirmed and further action is required. An additional 1,728 sites require assessment before it is determined what if any action is necessary.

Hazardous waste sites are affecting or threatening public or private water supply wells at 170 known locations. Many other sites have not yet been investigated, so it is not known whether they pose a threat to health, safety, public welfare, or the environment.

### 1989 in Review

Notable developments in Massachusetts' efforts to protect the environment during the past year include the following.

- \* The Commonwealth's environmental agencies expended a record \$80 million for the **acquisition and protection of critical open space**. A new Land Protection Agenda was established within the environmental agencies and a Rivers Policy was released by EOEA.

- \* A landmark **Toxics Use Reduction Act** was signed into law to set a statewide goal of reducing toxic waste generation by 50 percent by the year 1997.

- \* Important new **air quality** regulations were issued. The acid rain regulations required by the Acid Rain Control Act of 1985 were released in April. Reid Vapor Pressure regulations were established to prevent the evaporation of VOCs during refueling of automobiles.

- \* The passage in December of the **Cape Cod Commission Act** will allow for Cape Cod as a region to begin to address land use issues and projects of regional concern.

- \* Construction began on the **Springfield Material Recycling Facility**, which will be the nation's largest recycling facility, serving 85 communities and 700,000 residents by recycling 240 tons per day.

- \* A new and aggressive **enforcement policy** and Environmental Crime Strike Force were created and resulted in a record number of Administrative Penalties and some of the largest fines imposed for environmental violations in the history of the Commonwealth.

- \* The **ENVest** program welcomed private contributions to such programs as MASS RELEAF, an effort to plant shade and forest trees, and partnership programs in which companies were encouraged to contribute to the upkeep of nearby state parks, beaches and other facilities.

## Priorities for the Future

During the coming year, major environmental priorities for the Commonwealth include:

- \* enacting legislation and promulgating regulations agreed to with other NESCAUM states to require automobiles sold in Massachusetts to meet the current California auto emissions standards;
- \* enacting "greenhouse" legislation to significantly reduce the amount of carbon dioxide being released into the atmosphere;
- \* enacting watershed protection legislation to prevent development in sensitive areas near drinking water supplies;
- \* moving in the direction of no alteration or disturbance of wetlands, endangered species habitat, or other critical resource areas unless no possible alternatives exist, and requiring mitigation where impacts are unavoidable;
- \* enacting legislation that revises the current "grandfathering" provisions for subdivision plans to maintain protection only for viable projects actively being implemented;
- \* continuing to reform state agency permitting processes to reduce delays and provide greater certainty to permit applicants without sacrificing environmental objectives;
- \* issuing new, state-of-the-art regulations to further limit threats to the environment posed by solid

waste disposal facilities;

- \* continuing to work with regional groups around the Commonwealth to site and develop privately owned and operated Material Recycling Facilities (MRFs), and facilitating tax-exempt financing of such facilities;
- \* continuing efforts to develop new markets for glass, paper, metal, and plastic recycled material in cooperation with potential industrial and commercial users;
- \* implementing the 1989 Toxics Use Reduction Act, including the establishment of the new Toxics Use Reduction Institute, Council on Toxics Use Reduction, Toxics Use Advisory Council, and Office of Technical Assistance;
- \* continuing to review proposals to site facilities for the treatment, storage and disposal of hazardous materials so as to provide all necessary protections for public health, safety, and the environment;
- \* enacting the Endangered Species Protection legislation that would both make it illegal to destroy or "take" an endangered species and provide the first meaningful habitat protection;
- \* continuing to oppose any leasing of offshore areas for oil and gas exploration and drilling that would be inconsistent with state policies and objectives;
- \* promulgating new Tidelands and Harbor Planning regulations;

- \* providing first-rate public recreational opportunities to all of our citizens;

- \* continuing to aggressively enforce the law against those who intentionally or recklessly violate environmental laws, regulations, or permits.



## INTRODUCTION

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In 1989 the running aground of the Exxon Valdez and the subsequent desecration of the pristine natural environment of Prince William Sound, Alaska, was a grim reminder to us all that no corner of the globe is free from the risk of serious environmental degradation. But it is not only catastrophic events that endanger our environment and our quality of life. Consider a few indications of environmental problems a bit closer to home.

- \* TV and radio weather reports have begun to include information on air quality. It is not unusual during the summer months to hear that air quality is "unhealthful," and warnings to stay inside or reduce physical activity;

- \* Supermarkets now do a booming business in bottled water, as citizens no longer trust what comes out of the tap to be pure and safe;

- \* Traffic delays, scarce parking spaces and inadequate mass transit make going to work or to shop a more frustrating and time-consuming enterprise, not only in Boston but in many areas around the state;

- \* Schools and places of business are shut down due to the presence of chemical contamination;

- \* Unstaffed parks and recreation areas become unsafe for children and families while becoming more attractive to vandals and midnight dumpers of waste.

Our environment is constantly at risk through sudden impacts, insidious pollution, and gradual change. This first Annual Report on the State of the Massachusetts Environment addresses these issues.

In early 1989, after more than a year of deliberation, the Special Commission on Environmental Operations, chaired by former Senator Paul Tsongas, recommended that EOEA issue just such an annual report as this. Because this report is the first of its kind in Massachusetts, we have included certain information that in future years may not be present. Chapter I, for example, is an inventory of Massachusetts natural resources. We felt that before it was possible to address the quality of our environment, it was necessary to describe it. Chapter II provides a description of the cultural environment which we have created, how it has changed, our land use and settlement patterns, how we earn our livelihoods and to what extent we depend upon our natural resources for the production of goods and services. The information in these chapters is provided in order to set the stage for what follows.

In Chapter III we have described at some detail the most significant threats to the environmental quality of this Commonwealth. In future years it is expected that these subjects would be treated differently and perhaps in less detail. No attempt is made to compare or rank threats. In future years such comparisons may be useful in allocating public funds and establishing priorities.

Chapter IV represents the best information we could assemble over the past six months to actually assess the quality of our environmental resources. It

is the heart of this State of the Environment Report. Many of these data were not initially collected for this purpose but simply as the basis for one-time permit or programmatic decisions. The sum total of these data does not create as comprehensive a view of environmental quality in Massachusetts as we would like. In some cases the data present no more than anecdotal information concerning the quality of a particular resource. In future years it is expected that this will change; that our monitoring and data management efforts will be brought more in line with the kind of overall assessment required for a report such as this.

Chapter V offers a brief summary of environmental protection efforts nationally and within Massachusetts over the past twenty years. It also presents a summary of major accomplishments in the Commonwealth during the past twelve months. It is expected that this report will continue to include such an annual retrospective as a means of evaluating the success of our efforts in relation to our annual goals.

Chapter VI establishes goals and priorities for the next year and the next five years. It certainly does not represent all of the important future goals of the environmental secretariat; omissions from such a list are inevitable. It is also clear that these goals will have to be revised from year to year as we are presented with new information and unanticipated challenges.

The very act of completing an annual state of the environment report will promote change within the Commonwealth's environmental agencies. An effort such as this facilitates better understanding of the cross-media impacts of environmental problems and pollutants.

It reminds us that the only real indication of the success of our many programs is in whether or not the quality of our environment is improving. It is a good counter-balance to the tendency to create a new program each time a new problem is discovered and declare that mere act a success. This report should also encourage adjustments which will result in better coordination of agency, division, and programmatic goals.

Finally, it is important that, if those who are concerned with the quality of our environment find this report valuable, they encourage its production in the future. Researching and writing a report such as this is a significant undertaking. In the absence of demand from the public and the need to devote scarce resources to many other projects, future administrations may let this exercise lapse. The public's response will determine whether that is acceptable.

The Executive Office of Environmental Affairs welcomes your reactions to this report and suggestions for future reports. Please address your comments to:

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## CHAPTER I

### THE COMMONWEALTH'S NATURAL RESOURCE HERITAGE

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#### GEOLOGY AND NATURAL HISTORY

Twelve thousand years ago Massachusetts was covered entirely by glacial ice. The movement of the ice acted like a giant mill stone, abrading rock and carrying away the soft weathered portions which would later form our residual soils. The dynamics of the ice movement altered stream valleys and the direction of drainage. New rivers were created where none previously existed, and others were shifted into pre-existing river courses. The furthest extent of glacial movement built up terminal moraines and large outwash plains. Those land forms are now known as Cape Cod and the Islands of Nantucket, Martha's Vineyard and the Elizabeth Island chain ending at Cuttyhunk.

Many of our rivers, including the Connecticut, Merrimac, and Charles Rivers, follow the course of glacial drainage channels. In all of these river courses we find places where stream erosion resulted in an encounter with bedrock, and the ensuing changes in gradient created the fall lines which would eventually power the beginning of the American industrial revolution. The final and most permanent glacial effect was the sculpting and molding of the bedrock into the scenic vistas we call the Berkshires, the Holyokes and the Taconics.

Glacial till or "hardpan" soils covered most of the upland regions and formed the myriad of drumlin shaped small hills aligned in the direction of glacial movement. It is on such soils that our orchards have historically been

located. Meandering stream valleys such as the Connecticut flooded annually and became rich agricultural bottom land. The glacial outwash of permeable sand and gravel created aquifers and the sources of aggregate for modern construction materials.

A wide variety of bedrock types is found within the state. The far western region of Massachusetts contains large deposits of limestone and dolomite-type rocks formed prior to the formation of the Taconic Mountains. Farther east are found diverse rock types such as granite, gneiss, and schist in the Berkshire Hills. The Connecticut River Valley is composed of alternating layers of rich red sandstone and black extrusive volcanic lava flows. The bedrock in Central Massachusetts contains talc-bearing schists, iron and sulphur-stained schists, gneisses and granites. Eastern Massachusetts contains many metamorphic varieties of rock including argillites, some granites, quartzites and cambrian-aged shale. Southeastern Massachusetts, including Narragansett Bay, is underlain by sedimentary-type rocks of sandstone, siltstone, conglomerate and beds of meta-anthracite coal. This basin covers an area of 800 square miles and extends from the Blue Hills of Boston to Providence, Rhode Island. Cape Cod is entirely covered by glacial soils and contains no bedrock outcropping.

#### Topography

At the western edge of the state, the Taconic Range of hills approaches 3,000 feet in elevation and drains westerly

into the Hudson River system and easterly into the Housatonic Valley. It is here that the highest elevation in Massachusetts is found, the summit of Mount Greylock at 3,491 feet. East of the Taconics the Berkshire Range of hills, eroded and weathered mountains of the Appalachian chain, reaches elevations of 1,500-2,000 feet. This eastern mountain mass is geologically old, weathered, rounded rock composed mainly of metamorphosed sedimentary rocks which have more recently been faulted and folded, resulting in the low smooth topography of ancient mountain masses. These Berkshire hills, extending over the border into Vermont, become the Green Mountains.

Two interior lowlands, the Connecticut River Valley and the Berkshire Valley, are enclosed by uplands. The northern Connecticut River, constituting the Vermont/New Hampshire border, becomes the most important inland waterway in Massachusetts and Connecticut as it flows on its way to Long Island Sound. Red sandstone rock, rusty colored clay, and silt form the area's productive agricultural soils.

The eastern uplands, mainly in Worcester County, feature many areas approaching 1,000 feet in elevation. The Monadnocks, such as Mount Wachusett and Mount Watatic, are erosional remnants of once-lofty peaks. These rock units are extensions of New Hampshire's White Mountains and contain some of the uranium-bearing characteristics of those mountains.

The eastern lowlands, a zone of severely-eroded hills with elevations from 400 to 600 feet, were once a range of high mountains composed of volcanic rock separated by fast-moving mountain streams. The elongated Blue Hills of

Milton and Dedham are remnants of this range. The underlying hard non-soluble rocks of this region formed a rugged coastline of cliffs, crags and natural jetties projecting into the sea. These land forms, along with the sands discharged from rivers and streams and the terminal deposits of the last glacial age, make up the Massachusetts coastline as we know it today.

## Soils

The soils of Barnstable County have always been considered poor for agricultural purposes, forcing residents to turn primarily to the sea for survival. The soils in the area are acidic, sandy, subject to wind movement and affected by salt water and near-shore weather and chemistry. Bristol and Essex County soils are also acidic, but include clays and glacial till in the upland areas. Percolation or drainage is only average or poor compared with Cape Cod. Sloping areas eventually produced good hay and grain crops.

Worcester County has acidic soils and hilly areas composed of silty clay-like glacial till that were well forested with mixed hard and soft woods. Fruit orchards became and remain important to the region. Hampshire and Hampden Counties contain dark, rich flood plain and bottom-land soils which constitute the best agricultural land in the state. Rainfall is plentiful, water tables are high and flooding replenishes the soils in these two counties. Berkshire County contains the "sweet" or basic soils rich in lime and magnesium. Mixed hardwood forests dominate the two mountain chains in the county and the Hoosic and Housatonic River Valleys provide the flat, fertile land

which supported some limited agricultural activity.

## **MASSACHUSETTS ECOSYSTEMS**

Ecosystems encompass the biological and physical aspects of a site and their interactions. The term is generally used when functions such as the transfer, change, and use of energy and materials is the focus of interest. The structure of ecosystems is based on the natural plant communities even when topographic, geologic, and soil influences are the controlling factors. Natural communities are the functional units of the ecosystem, and most ecosystems have multiple community types within them.

The following is a discussion of some of the larger types of ecosystems and their component plant communities found in Massachusetts. This description of ecosystem and community types follows a general east-to-west gradient across the state, although many of the broad ecosystem types are statewide.

Many smaller natural communities are omitted though these are often significant in their contribution to the natural biodiversity of the state because they occur in unusual habitats that support uncommon species. Some of these small communities are found on cliff faces, rock outcrops, rocky headlands, fast-flowing streams and their banks, riverbank bluffs, oxbows, serpentine areas, sandstone, high elevations, and interdunal swales.

### **Estuaries and Tidal Marshes**

Estuaries are aquatic or wetland areas associated with tidal rivers,

occurring behind spits and barrier beaches, in river mouths and upstream. Intertidal mud flats and tidal marshes - salt, brackish, and freshwater - are included in the estuarine category. They occur from the seaward limit of freshwater influence to the upstream limit of tidal influence. The controlling influence is water with a variable degree of salinity and depth.

Estuaries are an interface protecting the upland from wave action and salt spray. Species inhabiting estuaries are adapted to fluctuating water levels, changing salinity and periodic desiccation.

**Tidal marshes** are often considered to be the nurseries of the sea, where many marine organisms spawn and feed. With their rapid plant growth, tidal marshes are among the most productive plant communities on earth. Mud flats are habitat for shellfish and other invertebrates, fed on by man and shore birds.

### **Dunes and Beaches**

These ecosystems occur in coastal areas that have less protection from waves and tide than do estuarine areas. **Barrier beaches** are narrow, low-lying strips of sand generally extending along the coast line. They absorb the impact of waves and are reshaped annually by storm action. These are very harsh environments. The sand substrate makes them very dry and nutrient poor, and salt spray, overwash, sun and wind are constant factors with which any organism living there must contend.

Dunes and interdunal areas move and replace each other. Some interdunal areas with a build-up of organic matter

have natural cranberry bogs, with an occasional rare orchid or even a small forest with southern tree species dominating.

Many species live within these constantly-changing conditions. Sand blows over a beach plum that resprouts. Migrating birds use slightly different areas for eating and nesting from year to year. Terrapins lay their eggs in the open sands of beaches.

### **Coastal Plain Ponds and Pond Shores**

**Coastal plain ponds and pond shores** occur in southeastern Massachusetts, primarily the Cape and Plymouth County, on glacial outwash sand deposits where blocks of ice were left by the receding glaciers 12,000 years ago. The melting of the ice left kettle holes in the landscape, and where the depression intersects the water table, there is a coastal plain pond. Because these are ground water ponds, with no inflow or outflow, they fluctuate with the seasonal changes in ground water levels.

There is a group of plants particularly adapted to being inundated in the winter, slowly drying out in some years and staying submerged in wet years. The ground waters flowing through the sands are nutrient poor and naturally acidic, and the plants growing along the shores of the ponds are good at using these conditions. When the ponds are held at consistently low levels or the waters are artificially enriched from faulty septic systems, the native plants lose their competitive advantages and the habitat is encroached upon by plants that are more widespread and not able to grow in the naturally difficult conditions of the unaltered pond shores.

The natural pond shores have a rich flora that includes many plants rare in Massachusetts and some that are globally rare. Several of the coastal plain pond shore dragonflies are globally or state rare species.

### **Sandplain Grasslands and Heathlands**

**Sandplain grasslands and heathlands** are upland ecosystems that occur primarily near the coast, in areas with sand substrate - glacial outwash plains that are easily drained and nutrient poor. Naturally-occurring grasslands and heathlands are probably maintained along the immediate coast by salt spray. These natural communities are open grasslands with only a few shrubs, including some that are adapted to withstanding the salt influence. An assortment of wildflowers can dominate as the season progresses - false indigo in midsummer and goldenrods later lend the grasslands bright colors. Without some force to discourage shrub and tree growth, scrub oak, pitch pine and huckleberry can overwhelm a grassland and convert it to scrub vegetation.

When settlers started clearing southeastern Massachusetts for farming and grazing, sandplain grasslands expanded. They were maintained by grazing and burning, a practice first used by Native Americans.

There are many rare plants limited to sandplain grasslands, and several species of birds frequent them. Research on the comparative advantages of mowing, burning and grazing grasslands to maintain the rare species and their habitat has been going on for several years. Fragmentation has resulted in very few large tracts remaining that can maintain the vegetation needed by the butterflies

and birds that use sandplain grasslands and heathlands. Short-eared owls and northern harriers have minimum space requirements for them to maintain territorial nesting areas, and small open space remnants do not supply adequate space.

### **Scrub Oak/Pitch Pine Barrens**

This is an open shrub-land ecosystem that also occurs on outwash sandplains. There is often a mosaic of scrub oaks, scattered pitch pines and grassland or heathland patches in lower areas called frost pockets. There are many acres of this natural community in southeastern Massachusetts and remnants in the Connecticut River Valley.

Many scrub oak/pitch pine barrens occur on good aquifers, and their development for human uses may threaten the quality of the water. This is a fire-maintained and -dependent community. Some of the component species depend on recurrent fires for their existence, and many of the species have volatile oils which actually encourage the spread of fires once they are ignited. Such species can sprout back vigorously once the fire has passed. Other species of invading trees don't survive the fire.

There are several species of butterflies and moths that depend on scrub oak/pitch pine habitats, and some of these require a thousand or more acres of scrub oak barrens to have enough larval food plants or successional stages to support their populations. The fragmentation of scrub oak/pitch pine barrens has been implicated in the loss of the Karner Blue butterfly from Massachusetts. Many acres of scrub oak/pitch pine barrens are in state parks,

wildlife management areas and town lands. There are many competing uses of these lands, and few have been managed to maintain the specific natural community type.

### **Freshwater Wetlands**

This is a major class of ecosystem, consisting of the interfaces between uplands and open waters of all types. There are multiple types of wetlands: peat (bog and fen) and nonpeat (marsh and swamp), acidic and basic (calcareous), forested and nonforested, nutrient poor (bogs) and nutrient rich (fens, swamps, and marshes). River flood plains, basin marshes, and seepage swamps are all freshwater wetlands. They all share the attribute of having water at or near the soil surface for all or part of the year, and the resulting stress on the plants that grow in them.

Wetlands provide habitat for many species of wildlife, some of which are rare. Often they are only part of the habitat needed by the species. For example, turtles and salamanders may spend part of their lives in wetlands and part in the uplands, which are not protected.

Several wetland natural community types are of special interest. Calcareous fens in Massachusetts, found mostly in Berkshire County, are our third most threatened natural community type. They are grassy peatlands influenced by the limestone rocks along the Housatonic and Hoosic Rivers. The state's endangered bog turtle, many rare plants, and several butterflies and moths occur in these limited habitats.

In the past, many calcareous fens were used as pasture, which may have

helped maintain them as open areas. Farmers have sometimes decided to improve pasturage by draining fens, which hasn't helped species dependent on the presence of cold, limy rivulets. Subdivision of ownership can affect drainage and water flow patterns to the detriment of the natural community. The best calcareous fens are in private ownership.

Another type of freshwater wetland that has limited distribution and has been heavily used historically is the Atlantic White Cedar Swamp which occurs throughout southeastern Massachusetts and a few small areas near Springfield. These were the historical source of cedar for shingles, shakes, and fence posts in Massachusetts, and the peat was mined for bog iron as early as the Saugus iron works operations in the 1600s. The early and successive cuttings removed the big old trees, and often left only red maple swamps. There are a few large examples left, including several in state forests, such as the Acushnet Cedar Swamp. One of the protections for these important wetlands is their reputation for being impenetrable. The outskirts may be used as dumps and old car graveyards, but more than 100 feet from the edge the interior is relatively undisturbed aside from historical cutting. It is not known why some disturbances produce red maple swamps and some revegetate as Atlantic White cedar.

### Forest Ecosystems

Nearly two thirds of the upland area of Massachusetts is forested. There are many types of forest that occur in a variety of conditions. Most of Massachusetts, especially the eastern and central portions, has acidic rock and soil. Acidic conditions usually support oak or

pine forest, the mix of species depending on the degree of dryness and disturbance history.

Most of Massachusetts' forest is second growth, with only small areas of old growth forest occurring in isolated pockets of unusual steepness or inaccessibility, such as occur on the Berkshire Plateau. When much of the state's agricultural land was abandoned in the mid to late 1800s, the new woodlands were often dominated by white pine and red maple, species that quickly establish themselves. Red maple is still a major component of many woodlands in Massachusetts.

Now the forests consist of a mix of northern hardwoods (sugar maple, beech, yellow birch, white ash) and pines on the less acid, less dry sites. Drier sites with southeastern exposures often consist of a mix of oaks and hickories, with a sedge lawn below. The dry acid soils and granite bedrock of Worcester County support oak, pitch pine, and red maple forests with an undergrowth of huckleberry and blueberry bushes. Hemlock trees form a thick canopy in ravines and along the upland edges of swamps. Cove forest in the southern part of the state may be dominated by southern species such as tulip tree and black gum. Rich mesic forests, beech-maple forests, of the western part of the state support a rich spring flora and a relatively open understory.

The current forest communities differ from the forests of earlier times. American chestnuts dominated many of what are now oak forests until the advent of the chestnut blight in the early 1900s which killed the mature trees and keeps the sprouts from reaching adult size. Dutch elm disease effectively removed

American elm as an important forest species. Several of the forest tree species (sugar maple, spruce, and ash) are in decline from unknown causes. An abundance of insects and diseases, mostly exotic, are attacking tree species. Coupled with decline caused by other stresses, the various imported diseases can have serious local effects on tree survival. One possible explanation of the decline is that pollutants and acid rain have weakened trees so that drought and disease and other secondary infections may have a much greater effect than they would on healthy trees.

When one tree species is lost, as in the case of the chestnut, other species depending on it will also be lost. It is estimated that at least six species of insect associated with the American chestnut became extinct after the chestnut blight killed the trees. The problem of forest interior is of a different sort. Some species of birds have been shown to be able to breed successfully only in the interior of forest, because there are edge-dwelling predators that prey on their eggs even up to half a kilometer from the forest edge. Much of the Massachusetts forest is in small parcels, dissected by roads or otherwise fragmented. The need for large parcels with large interiors has only recently begun to be considered by the various state agencies that control land.

Vernal pools are a unique habitat within the forest. Vernal pools are part of the water retention system of the forest. They are depressions that contain water for only part of the year and are often a breeding place for many amphibians, including salamanders and frogs. Reproductive difficulties in salamanders can be an early warning of soil and surface water acidification.

There is a large forest resource in Massachusetts and only abnormal conditions threaten the whole. The loss of some of the rarer plants and small animals may be providing early warning. Additional monitoring and analysis is necessary to take advantage of the information available. Without such studies, the chance may be lost to protect the ecosystems and the humans living in these ecosystems and breathing the same air.

## FOREST RESOURCES

Massachusetts has a total land area of over 5 million acres. With 3,225,000 acres of forest land, the Commonwealth is nearly 63 percent forested. Ninety-one percent of this forest land is classified as timberland or commercial forest, producing or capable of producing crops of industrial wood (more than 20 cubic feet per acre per year).

The saw timber stands have increased 61 percent from 1972 to 1985, the interval between forest surveys conducted by the Forest Inventory and Analysis Unit, Northeastern Forest Experiment Station, and USDA Forest Service. Saw timber stands are now at a total of 1,640,900 acres or 56 percent of the timberland. Seventy-eight percent of the timberland, or 2,286,300 acres, has a growing stock volume of more than 1,000 cubic feet per acre.

A brief look at the history of the Commonwealth shows that, since the coming of Europeans, the forests of Southern New England have undergone extensive changes. As the Europeans moved onto the land, they cleared it for farming. By 1820, about 30 percent of

Massachusetts was still forested. Farming flourished in Southern New England, but in 1830, with the opening of the Erie Canal, its fate was sealed. By 1850, it was becoming evident that the small stony farms of New England could not compete with the larger, more fertile farms of western New York, Ohio and Indiana. People in Boston were eating bread made from wheat that had traveled hundreds of miles.

As land went out of farming, it reverted to forest. In many areas this new forest was mostly white pine, a species that was found scattered through the original forest, but not a predominant species. In the early years of this century, until about 1920, an extensive white pine logging industry flourished. This industry produced boxes, pails, and barrels primarily for shipping fish products inland and overseas.

The advent of the portable sawmill permitted the purchaser to move onto the land, cut off the pine, and move out, leaving behind the hardwoods, slab piles and sawdust. Frequently, operators purchased the land and timber in one lump sum and high-graded it; they took the best and left the worst standing. This practice hastened the development of poor-quality hardwood stands to take the place of the white pine. After 1930, this industry began to decline because of the emergence of other packing materials and the fact that most accessible pine had been cut.

## Forest Types

There are nine forest types in the Commonwealth that have been defined by the Continuous Forest Inventory system. The following is a list of the indicator species for each type: Red Spruce, Balsam

Fir, White Spruce, Sugar Maple, Beech, Yellow Birch, Black Oak, Pitch Pine, and Bear Oak. These forest types are found in six vegetation zones which were specified by the Silvicultural Committee of the New England Section of the Society of American Foresters in 1952.

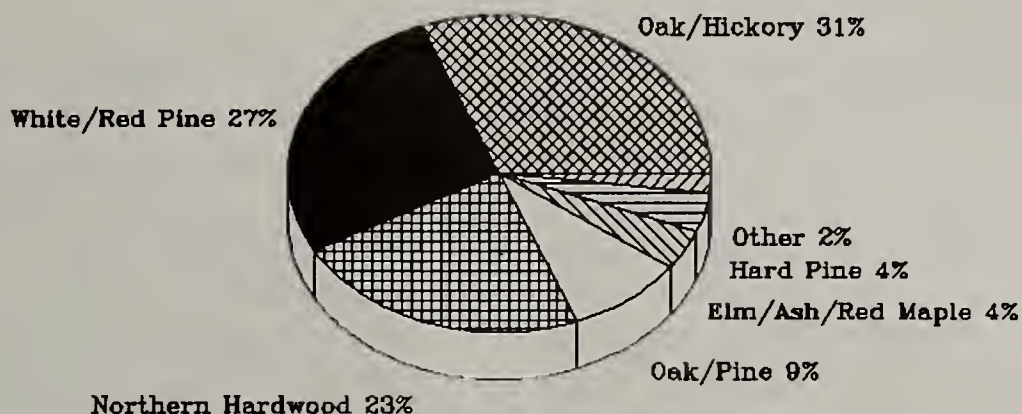
The Spruce-Fir-Northern Hardwoods Zone is found mainly at higher elevations in the Taconics, Berkshires, and a few scattered areas in the Central Highlands. The forest types in this zone are Red Spruce, Balsam Fir and White Spruce. Pure stands are usually limited to sites with thin soils at higher elevations. In most other locations, the spruce and fir gradually become a mixture containing species found in the Northern Hardwood Zone.

The Northern Hardwoods-Hemlock/White Pine Zone is found mainly at higher elevations where soil and climate are more favorable than in the Spruce-Fir Type. In this zone, the forest types are Sugar Maple, Beech and Yellow Birch. This type is located mainly in the Berkshire, Taconics and other heavy soil areas in the western third of the state. Gradually, this type becomes the Transition Hardwoods-White Pine-Hemlock type in the east.

The Transition Hardwoods-White Pine-Hemlock Zone, a composite of two other major types, lies between the Northern Hardwoods to the west and the Central Hardwoods to the east and south. Where the climate moderates, the Northern Hardwoods mix with the Central Hardwoods, and thus there is an increase in the variety of species found.

The Central Hardwoods-Hemlock-White Pine Zone occurs on many of the remaining sites not occupied by the

## AREA OF MASSACHUSETTS TIMBERLAND BY FOREST-TYPE GROUP - 1985



Data Source: Department of  
Environmental Management

Transition Hardwoods. It is sometimes referred to as the Oak-Hickory type and the forest type is the Black Oak. The more moist sites contain the widest variety of species. Some of the more sandy soils provide ideal sites for white pine - some of the best stands of white pine in the eastern part of the state are located in this zone.

The Central Hardwoods-Hemlock Zone is found in a very limited part of the Commonwealth in the Fall River area. The topography is generally level with rather poor soils and swamps and wetlands are numerous. The forest type is Black Oak. Hickories are not numerous even though this is a Central Hardwood type.

The Pitch Pine-Oak Zone in Massachusetts occurs on Cape Cod and the Islands. It is primarily the result of frequent disturbances, the most common

of which is fire. Most of the soils in this area are poor, and coarse sandy soils predominate. There are mostly Scarlet and Black Oaks and the forest type is Pitch Pine and Bear Oak. The terrain is mainly level, with scattered ponds and lakes.

The forests of Massachusetts contribute significantly to the economy and environmental quality of the Commonwealth. Almost two thirds of the total land area is forested - an astounding figure given that Massachusetts is the third most densely populated state in the nation. Moreover, the forests supply not only wood products, but recreation opportunities, wildlife habitats, clean air and water, and visual amenities. Few resources provide such a variety of benefits for people.

To understand adequately the significance of Massachusetts forests, all

the resource values must be included. Too often forest resources are considered synonymous with timber, and forest management is viewed only as producing wood products. While many recognize the necessity of providing wood products for commercial and residential use, forest management is too seldom seen as an important tool for providing recreation, water, and wildlife opportunities. The forest management activities such as thinning, pruning, and harvesting trees are significant because they open scenic vistas on roads and trails; increase water yield in streams and reservoirs; create edge and openings to foster wildlife species; open roads in the forest for recreational use; and provide healthier, higher quality trees in residual forest stands. This is why recreation, visual amenities, wildlife, wood, and water are all considered forest resources and producing a balanced flow of these benefits is a part of sound forest management.

In Massachusetts, 85 percent of the commercial forest land is privately owned, mostly by land owners with tracts of between one and twenty acres. Collectively, this group numbers 235,000 owners who hold almost one million acres of land. Most of these owners hold their land for residential, recreational, or investment purposes; fewer than 4 percent are interested in timber production.

The Commonwealth administers 13 percent of the commercial forestland, primarily through three state agencies; the Department of Environmental Management, the Metropolitan District Commission, and the Department of Fisheries, Wildlife and Environmental Law Enforcement. Most of these state lands are managed for multiple uses.

Cities and towns administer some

288,000 acres of land primarily in water supply lands, conservation lands, recreation/park lands, and town forests. Municipal watersheds comprise about 5 percent of all land in the Commonwealth. The majority of communities prohibit any recreational use of these lands.

The forests of Massachusetts are important to the economic stability and quality of life of the Commonwealth's citizens through improved forest management, air, soil and water stewardship, resource use, and other multiple-use activities on private and public woodlands. It is important to keep these green spaces both naturally productive and income producing so that they are not over-developed.

## **WATER RESOURCES**

### **Rivers and Streams**

The rivers of Massachusetts were formed as glaciers carved, heaved and furrowed the bedrock and deposited the soils and rocks that filled the shallows and shaped the hillsides. These geological shapes, combined with the usually abundant precipitation in New England (45 inches compared with less than 10 inches for New Mexico or 30 inches average for the continental U.S.), form today's river beds and flood plains and the ponds, streams, wetlands and groundwater systems which all feed the rivers on their individual journeys toward the ocean.

The rivers of the Commonwealth are an essential feature in the ecological systems that support all life here. From the small hillside trickles carrying nutrients and sediments to lower resting places, to the estuaries at river mouths

# Rivers and Streams of Massachusetts



Data Source: USGS-NMD 1:100,000 DLG's

Scale: 0 10 20 30 40 50 miles  
0 10 20 30 40 50 kilometers



where fresh and saltwater mingle to create a nursery for numerous fish, birds, ocean creatures and other animals, the rivers sustain life and shape the landscape. Long before Europeans settled in this area, the rivers were crucial to the survival of Native Americans who relied on them for food, materials, transport and water. Much later, new settlers utilized the rivers for power, transportation, new forms of trade and defense. Like the built systems that keep energy, information, water and materials flowing through the Commonwealth, rivers provide the natural infrastructure that conducts the water, nurses the fisheries, nourishes the wetlands, feeds aquifers, reservoirs and ponds, produces energy, irrigates agricultural lands, serves as thoroughfares for migrating or foraging fish, birds and other animals, receives wastewater and generally provides the foundation for wildlife and human settlement.

The character of the state's rivers is as diverse as their size. Western Massachusetts rivers and streams tend to have steeper slopes and faster-flowing water, and are often capable of sustaining native cold-water fish such as trout. East of the Connecticut River, the terrain tends to flatten out. The gradient of the rivers is less than that of those farther west, water flows more slowly, and flood plains are wider. Temperatures are warmer and capable of supporting warm-water species. East coastal rivers run directly into the sea, providing rich estuary areas which are highly productive for shellfish, anadromous and sea fish. Cape Cod streams are small and self-contained.

More than 2,000 named rivers and streams flow for more than 10,700 miles throughout Massachusetts. The rivers range from sprightly rushing upland

streams to meandering slow-paced rivers surrounded by wetlands. Depending on the soils in the area, a river may have a narrow, rocky channel, or a wandering, soft-banked path.

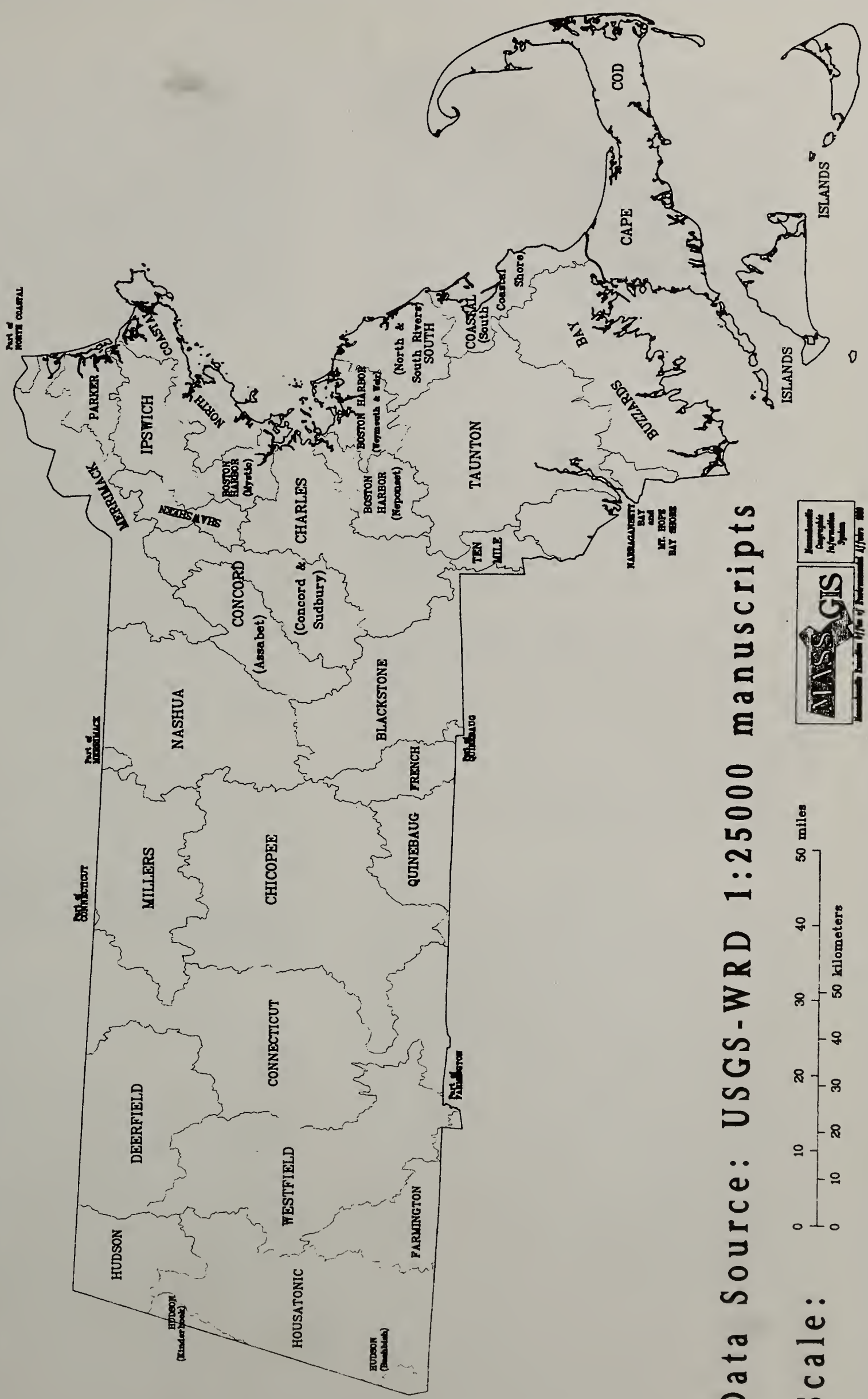
A river basin is defined by state law (the 1983 Interbasin Transfer Act regulations) as the geographic area of land that drains water into a particular river. Precipitation moves from the highest points of a basin through the soils or along the surface contours of earth or rock toward the lower areas of the basin, where the river runs. The Massachusetts Water Resources Commission, the state's water resources planning and policy body, has delineated 27 major river basins on the mainland, plus a 28th watershed, the Massachusetts Coastal Basin which includes Commonwealth waters below mean high tide.

Eleven of our 27 major river basins cross state boundaries; most involve one other state, but the Connecticut courses through three other states; New Hampshire, Vermont and Connecticut. In these basins the condition of our rivers is of immediate concern to our neighboring states.

The largest basin in the state is the Merrimack, which drains 1,200 square miles of land. The Chicopee is the second largest basin draining 720 square miles, and the Housatonic, Nashua and Taunton all cover between 530 and 550 square miles each. The smallest basin is the Weymouth and Weir at 42.3 square miles. The state's longest mainstem river is the Connecticut which runs north and south from the Vermont/New Hampshire border to Connecticut for 66 miles.

Most of these rivers, in all their diverse characteristics, have been put to

# Major Basins Of Massachusetts



human purposes. After nearly 400 years of hard work, many of the Commonwealth's rivers bear signs of abuse. When Massachusetts was first settled by Europeans in the 1600s, much land was cleared for agriculture, changing runoff, land contours, and groundwater patterns. The Industrial Revolution brought mills and other industries which relied on rivers for water power and waste removal. Vast businesses were built upon the water power of the rivers. It was assumed that rivers could absorb infinite amounts of pollutants, supply infinite amounts of water, and sustain extensive impoundment, redirection, channelization and diversion. Since the mill days our rivers have been used continuously for water supply, food sources, energy and disposal of human and industrial wastes.

Based on 1980 data, the most recent available from the U.S. Geological Survey, the state's surface waters are used as follows: 69 percent for public drinking water, 26 percent for self-supplied industrial uses, two percent for irrigation and livestock. Sixty-seven percent of the state's population relies on water supplies from surface water.

The Merrimack River alone provides water for more than a quarter million Massachusetts residents as well as for ten New Hampshire cities and towns. The Quabbin and Wachusett Reservoirs are fed by the Swift, Ware, Stillwater and Quinnepoxet Rivers respectively, and serve 2.5 million people in the metropolitan Boston area. These rivers provide over half of the state's population with its water supply. In addition, many rivers are connected to groundwater supplies. Wells located near rivers (such as the Charles and Ipswich) can draw from them during dry periods.

Rivers supply water to industrial and commercial users ranging from manufacturers who need cooling or processing water to farmers who need irrigation waters. Some 20,000 acres of farmland are irrigated. Twelve thousand of those acres are involved in the state's cranberry industry. In addition, the state has licensed hydropower dams generating over 308,000 kilowatts of electricity.

Rivers provide a tremendous range of recreational opportunity, from quiet contemplation to vigorous whitewater canoeing and kayaking, nature observation and birdwatching, rowing, sport fishing, and historic or cultural sites of interest.

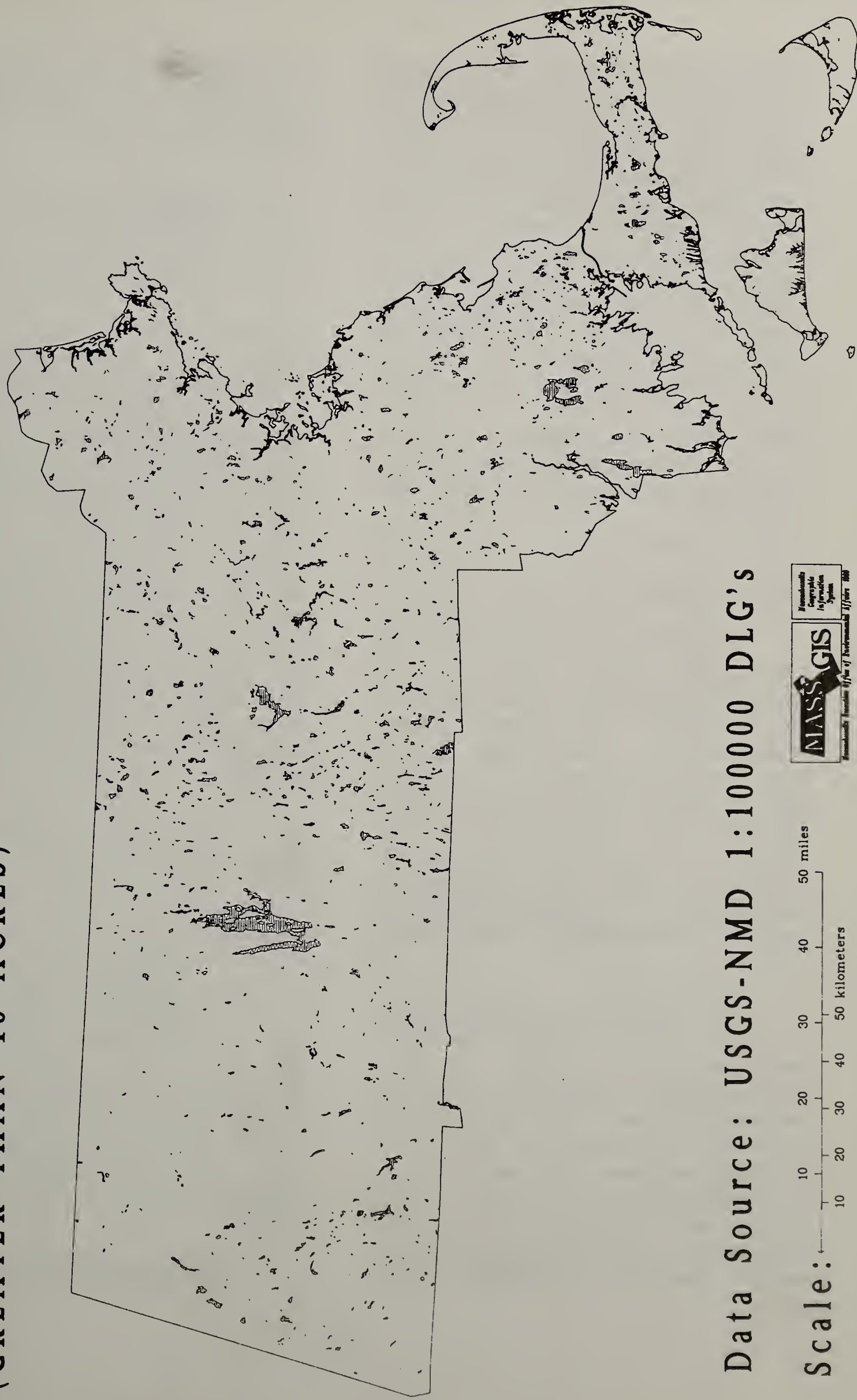
Shellfishing and commercial fishing are major businesses for the state. Seventy percent of all commercial fish and shellfish depend on estuaries at river mouths for spawning or nurseries. Each acre of the Atlantic coast wetland-estuary system is capable of producing up to 125 pounds of commercial fish.

Rivers and their corridors also have special value as habitat for a great variety of plants and animals. A large number of animals depend on rivers for some part of their life cycle. Protected areas along rivers are particularly important as travel paths, foraging areas and in some cases breeding grounds.

Almost all the state's river basins are home to some rare or endangered species. Basins with the largest concentrations tend to be those with unusual soil conditions for the state, such as the Housatonic, the Connecticut, Deerfield, Hoosic and the Cape and Islands. Elevation and features such as the meandering paths of the Housatonic and Connecticut also encourage diversity and unusual species.

The years of industrial use of and

# Wetlands and Lakes of Massachusetts (GREATER THAN 10 ACRES)



Data Source: USGS-NMD 1:100000 DLG's

Scale: 10 20 30 40 50 miles  
10 20 30 40 50 kilometers



human intervention in our river systems has caused some as yet unremedied problems, particularly with water quality, caused by both point and non-point sources of pollution. Non-point pollutants - those that come from road run-off, agricultural chemicals, spills and other sources - are an increasing, not decreasing, threat to current and future water quality. Land uses adjacent to rivers remain of significant concern due to clearing of vegetation, soil disturbance, erosion and sedimentation, spills, leaks or inappropriate placement of septage systems or hazardous facilities. No more than two percent of riverfront land is now under public or private non-profit protection.

## Lakes and Ponds

Massachusetts is graced with some 2,871 lakes, ponds, reservoirs, and impoundments ranging in size from less than an acre to 25,000 acres. These bodies comprise a total surface area of more than 150,000 acres. Of the total number of lakes, 1,638 have an area of 10 acres or more, equal to approximately 145,000 surface acres, 96 percent of the total. Thus a rather large number, 1,233 or 43 percent, of relatively small lakes account for the remaining 5,000 surface acres.

Lake depths range from only a few feet to 150 feet, but most of the small lakes tend to be quite shallow. In many lakes throughout the Commonwealth, the shallow condition is due in part to silt and sand from construction activities in the watershed, storm drain discharges, or the accumulation of partially-decayed aquatic plants. Generally, shallow lakes tend to be more productive because sunlight penetrates to the bottom so that

populations of aquatic vegetation and microscopic algae (particularly greens and bluegreens) can flourish when plant nutrients are abundant.

The shapes of lake basins are highly variable throughout the state. Many of the smaller water bodies were formed during the last glacial period when huge blocks of ice were buried by outwash material. In time, these ice blocks melted to form lake basins of vastly different shapes, particularly on the Cape Cod peninsula and in southeastern Massachusetts. The deep elongated shape of Lake Quinsigamond, east of Worcester, is the result of large masses of bedrock slipping along a fault line. Many of the rivers and streams of the state were obstructed by dams built during the Industrial Revolution, resulting in a large number of mill ponds. Similarly, dams have been constructed during this century to create water supply reservoirs such as the Quabbin. Lakes formed in this manner take the shape of the river basin and adjacent lowland that is subjected to flooding.

Water chemistry in Massachusetts lakes, particularly natural lakes, varies widely from the alkaline lakes in the Berkshire Hills which are relatively rich in calcium and well buffered against the effects of acid rain, to the poorly-buffered, low-calcium lakes on Cape Cod. Many bogs and lakes have a high dissolved organic content from decayed plant material, which absorbs certain wavelengths of sunlight, which in turn causes the water to appear dark brown-orange. The basic components of lake water quality are a result of regional conditions such as the type of soil and bedrock.

Much of the Commonwealth,

including the central region, most of the coastal region, and a band between the Berkshire Hills and the Connecticut River Valley, is composed of deposits that are virtually devoid of calcium carbonate. Generally, surface waters associated with these regions are acidic, characterized by low pH (high acidity), alkalinity, and hardness.

Three other regions have deposits that are high in carbonates and thus yield more alkaline waters usually characterized by high pH (low acidity), alkalinity, and hardness. These regions are the western limestone belt of the Berkshires, the central and southern Connecticut River Valley, and a small region of the northeastern coast. Variation in the pH, alkalinity, and hardness of the water has a profound effect on the species populations that can be found in a lake. For example, the nuisance plant called Eurasian milfoil grows so luxuriantly in lakes of the Berkshire Hills region that hundreds of thousands of dollars have been expended by cities, towns and the state to combat its infestations. Lakes in most other regions of the state do not support excessive growth of Eurasian milfoil, but they may be affected by other species.

Beyond these basic chemical characteristics, lake conditions are as varied as the streams, rivers, or groundwater that feed them. In general, lakes act as a temporary sink for the nutrients and sediments that are continually being removed from the land. The relative size of their watersheds in comparison to the lake and the rate at which materials are removed from the watershed to the lake will largely determine their ultimate condition. Typically, as time passes, the condition of a lake will pass from a nutrient-poor state

to a nutrient-rich state, a process termed eutrophication. The rate at which these changes occur is naturally quite slow, often measured over thousands of years. Unfortunately, in Massachusetts, as in much of the United States, unchecked development along shorelines and in watersheds has greatly accelerated the rate of lake enrichment. The outwardly-visible signs of this process, excessive growth of weeds and algae, are pervasive throughout the small and medium-sized shallow lakes of Massachusetts.

Many historically important lake uses have been maintained or expanded while others have been replaced by new uses. Lakes have remained important for drinking water supply, fishing, boating, swimming, and irrigation (particularly for cranberry bogs), while such uses as hydropower and ice harvesting have diminished.

Lakes are a major source of drinking water. Eight of the eleven largest bodies of fresh water have been created or designated for that use. This includes 25 percent of the 150,000 acres of surface water in the state. Jurisdiction for these and other such bodies rests with specified units of state or municipal government including the Metropolitan District Commission, Massachusetts Water Resources Authority, and the Massachusetts Department of Environmental Management.

Recreational uses of lakes have become increasingly important in Massachusetts. Most communities and state parks have at least one beach developed as a swimming area. The boom in the power boating industry has led to increasing user pressure in contrast to more traditional boating activities such as sailing, canoeing, and rowing. An

increase in fishing pressure is being exacerbated as the number of lakes with quality fisheries is reduced, a consequence of eutrophication and acidification.

## Groundwater

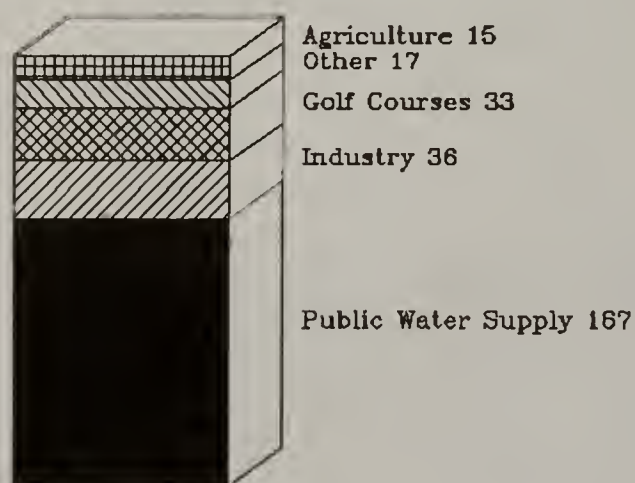
Sources of groundwater in Massachusetts exist primarily in loose, unconsolidated (sand and gravel) aquifers. Consolidated bedrock aquifers yield water in smaller quantities, primarily to domestic and small-scale public supply wells. An aquifer is a water saturated geologic area capable of yielding sufficient quantities of water to wells or springs to make them viable sources of drinking water.

Water in sand and gravel aquifers is stored and transmitted through pore spaces separating soil particles. Water in bedrock aquifers is derived primarily from pore spaces in the form of fractures, faults, joints or cavities in the rock. Both

types of aquifers are susceptible to contamination but exhibit very different hydrogeologic characteristics that influence successful contamination assessments or remediation.

Groundwater resources are not distributed evenly throughout the Commonwealth. A map portraying the location of medium- and high-yield aquifers is shown on the next page. The U.S. Geological Survey's Hydrologic Atlas is the primary source of information on groundwater resources. Aquifers are mapped by river basins and hence all summary data are shown on that basis. Historically the definitions for high- and medium-yield aquifers have varied from basin to basin as mapping efforts have taken place at different times. High-yield aquifers are most often defined as capable of yielding over 300 gallons per minute (gpm). In some basins high-yield aquifers were mapped on the basis of yields

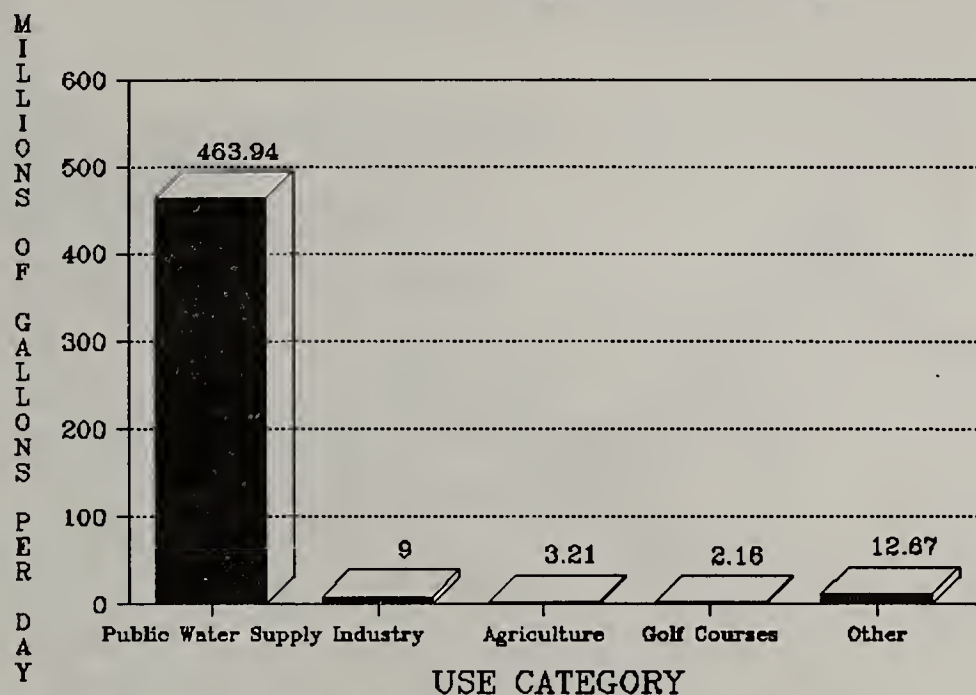
### GROUNDWATER USE BY CATEGORY REGISTERED WITHDRAWALS OVER 100,000 GPD\*



Registered Withdrawals by Type

Data Source: DEP Division of Water Supply  
\* gallons per day

# GROUNDWATER WITHDRAWALS BY VOLUME MILLIONS OF GALLONS PER DAY



Data Source: DEP Division of Water Supply

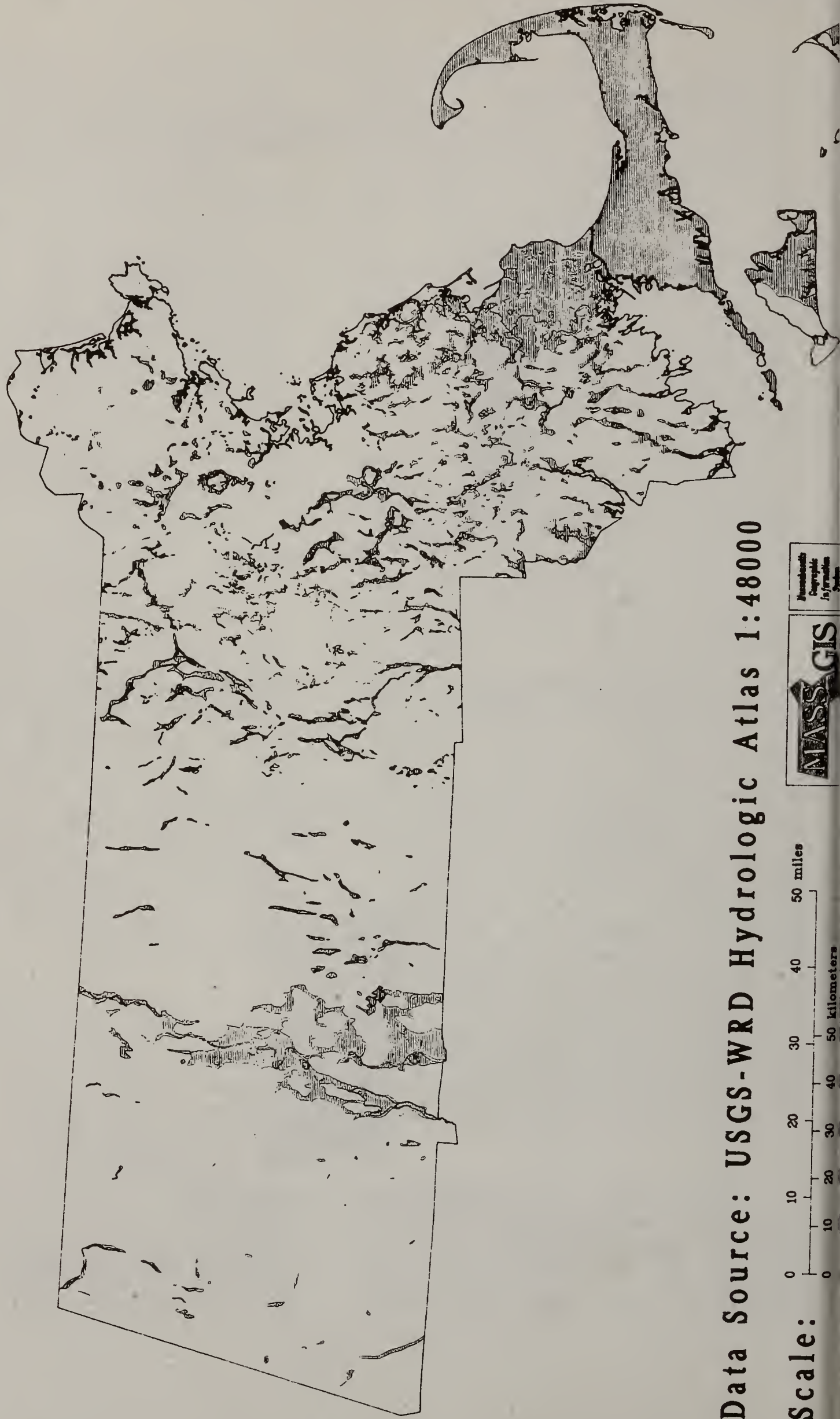
greater than 250 gpm, 200 gpm or other variations. Medium-yield aquifers are most commonly defined as having potential flows of 100 - 300 gpm but that characterization has also varied from 25-1000 gpm, 100-200 gpm or 50-250 gpm depending on the basin. In spite of these idiosyncrasies, the data are helpful in understanding spatial distribution. Furthermore, based on all the above definitions, it is possible to estimate that 16.2 percent of the total area of the Commonwealth is underlain by high- and medium-yield aquifers. Yet, because of these differences in definitions of high- and medium-yield aquifers, comparisons of data across basins would be misleading.

One third of Massachusetts residents rely on groundwater sources for drinking. There are 275 cities and towns supplying over two million people with groundwater from 1,600 public water

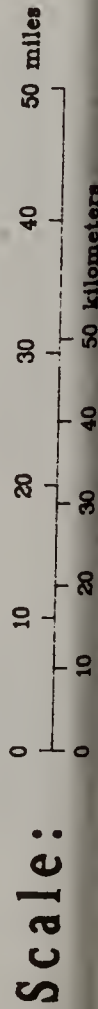
supply wells using over 1,200 groundwater sources. Over 400,000 residents, seven percent of the population, have private wells. All told, 55 percent of the communities in this state are totally dependent on groundwater supplies and an additional 24 percent use a combination of ground and surface water sources. The average daily demand for water in Massachusetts is 765 million gallons per day (gpd).

Groundwater is basic to our survival in other ways. Not only is it vital to humans, animals, vegetation and the ecological process as whole, it is also important to the economy. Seventy-six percent of the industries in Massachusetts rely on groundwater for manufacturing and cooling. It is also used in energy cogeneration plants. With such a dependence on this resource, it is crucial to protect both the quality and quantity of the groundwater we have.

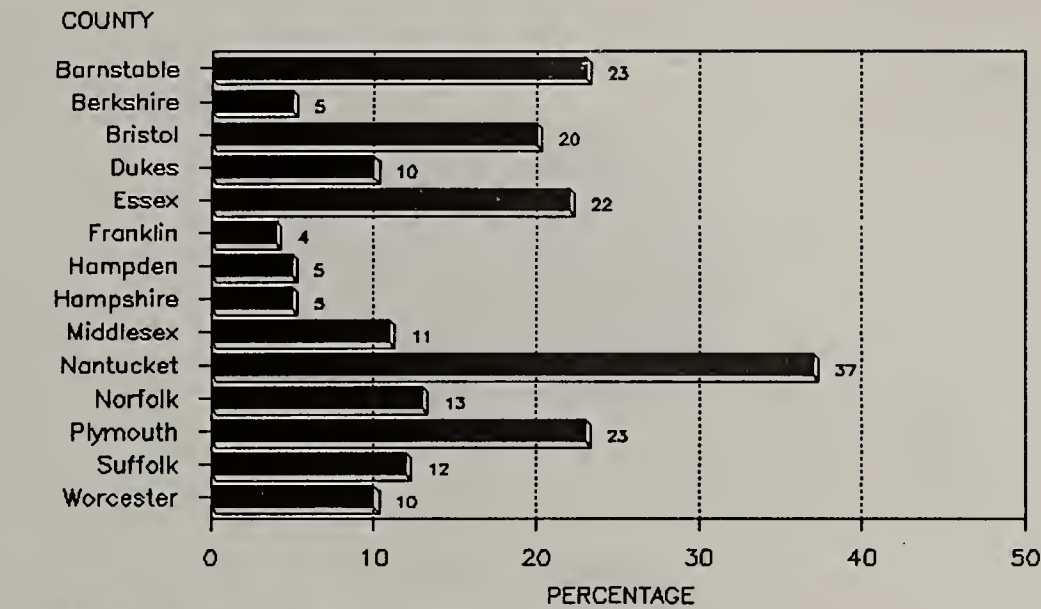
# Medium- and High-Yield Aquifers of Massachusetts



Data Source: USGS-WRD Hydrologic Atlas 1:48000



## PERCENTAGE OF EACH MASSACHUSETTS COUNTY OCCUPIED BY WETLANDS



Data Source: National Wetlands Inventory, U.S. Fish and Wildlife Service

The Water Management Act (MGL Chapter 21G) was passed in 1985 with the expressed purpose of regulating the state's surface water and groundwater withdrawals in order to ensure adequate water supplies to meet current and future needs and to maintain the integrity of environmental resources. There are 961 registered water withdrawers in Massachusetts. As of January 1, 1988, there were 268 registrations for groundwater-only withdrawals in excess of 100,000 gallons per day and an additional 208 using a combination of groundwater and surface water.

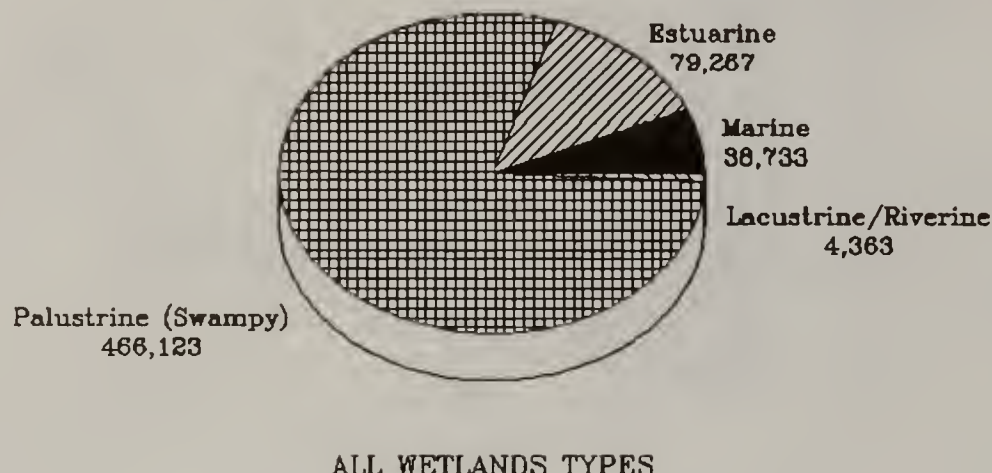
## WETLANDS

Massachusetts had nearly 590,000 acres (920 square miles) of wetlands in the mid 1970s representing about 12 percent of the state's land area. Almost 80 percent of the state's wetland resources

is palustrine (swampy) wetland. Swampy forested wetlands predominate, accounting for nearly 330,000 acres or roughly 71 percent of the state's forested wetland and 56 percent of the state's entire wetland resource. Twenty percent of the state's wetland inventory is tidal wetland (marine and estuarine wetlands). Estuarine emergent wetlands (salt and brackish marshes) are the dominant tidal wetland type, accounting for nearly 48,000 acres and representing nearly 40 percent of these wetlands. Tidal flats are almost as abundant as the estuarine marshes, totaling about 43,500 acres and representing about 37 percent of the state's tidal wetlands.

Wetland characteristics may change and acreages may increase or decrease in response to natural factors. For instance, natural succession of plant communities and increased beaver populations were the greatest factors associated with wetland

## MASSACHUSETTS WETLANDS ACREAGE BY TYPE



Data Sources: National Wetlands Inventory  
U.S. Fish and Wildlife Service

alteration in Massachusetts between 1951 and 1977. Agriculture, road construction and development are the other chief causes of wetlands loss in the Commonwealth.

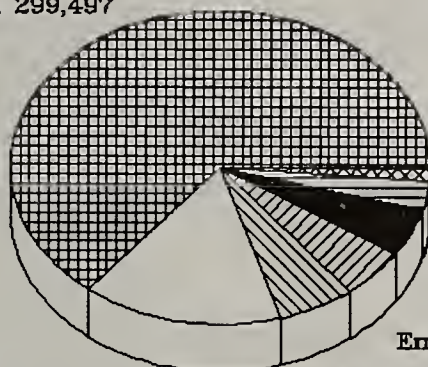
Wetlands are also influenced by rise in sea level. Mean sea level has risen 350-400 feet during the last 12,000 to 15,000 years and the shoreline has retreated many miles over that time. In recent times the rate of sea level rise has been approximately one foot every 100 years, but is predicted to increase dramatically over the next 60 years. A 1989 report from the Massachusetts Office of Coastal Zone Management provides scenarios ranging from 1.8 feet to 11.3 feet rise in the next 100 years. The rate of retreat varies for other areas on the Massachusetts coast depending on such factors as exposure and frequency of storms, types of shoreline material, and extent of shoreline alterations. The pace

of sea level rise has also been linked to the amount of global warming gasses emitted worldwide. The warmer the upper atmosphere (stratosphere), the more the ocean will expand and rise.

Two thirds of the major species of U.S. commercial fish and shrimp feed in wetlands or on wetlands-produced food. Many fish use wetlands as nursery grounds and almost all important recreational fish spawn in wetlands. Other wildlife need wetlands as well. Migratory waterfowl and other birds use wetlands as breeding grounds, overwintering areas, and feeding grounds. A study of eight western Massachusetts wetlands revealed a total of 46 breeding species. Furbearers such as muskrats, beavers, otters, mink, raccoons, skunks and weasels are found in wetlands. Other mammals found in wetlands are mice, bog lemmings and shrews. Reptiles including water snakes and the endangered Plymouth red-bellied

## PALUSTRINE (SWAMPY) WETLANDS ACREAGE BY SUB-TYPE

Deciduous Forested 299,497



Other\* 5,811  
Cranberry Bogs 14,194  
Open Water/Aquatic 23,000

Emergent 24,240

Evergreen Forested 27,415

Deciduous Shrub 71,928

Data Source: National Wetlands Inventory  
U.S. Fish and Wildlife Service  
\*Includes Evergreen Shrub & Dead Forest

turtle are dependant on wetlands, and nearly all of the 190 North American species of amphibians including frogs and salamanders are dependent on wetlands at least for breeding.

Wetlands improve water quality by removing nutrients, especially nitrogen and phosphorus. They temporarily store flood waters and reduce storm damage by slowing wave velocity and lowering wave heights and, thus, lessen water's erosive potential. In a 1960s study of flood prevention potential in the Charles River Watershed, the Army Corps of Engineers concluded that if wetlands in the upper and middle watershed were destroyed it would cause an estimated annual flood damage cost of \$17 million.

Wetland vegetation reduces erosion by increasing the durability of sediment through binding with roots, dampening waves and reducing current velocity

through friction, and facilitating the buildup of sediment. Wetlands produce timber, fish, shellfish, wildlife, peat, blueberries, wild rice, and hay. The \$90 million cranberry industry in Massachusetts depends on natural and man-made bogs. Wetlands are also important actual and potential sources of drinking water supply. Currently, at least 60 municipalities have public wells in or very near wetlands.

There are wetlands in all counties of Massachusetts. The coastal counties have the greatest percentage. Barnstable, Bristol, Essex, Franklin and Plymouth have wetlands covering between 20 and 23 percent of their areas. Nantucket has the largest relative wetland area, almost 40 percent of the island. Moving inland, the wetland areas decrease from 10 percent in Worcester County to five percent in the Berkshires. The Connecticut River Valley counties of

Franklin, Hampden and Hampshire is only four to five percent wetlands.

## COASTAL RESOURCES

The Massachusetts coast winds and meanders over a 1,500 mile length of rocky shore, sandy beaches, productive estuaries, fragile salt marshes, massive urban harbors, smaller town harbors and marinas, wide open spaces, tidal flats, and dozens of islands. It is one of the longest state coasts in the country - longer even than that of California due to its numerous capes, coves and estuaries.

The forces that shaped the Massachusetts coast were set in motion approximately 15,000 years ago during the last great Ice Age. As the glaciers moved south, they scraped bare what became rocky headlands of the north shore. As they retreated they left behind the moraines of sand and gravel that formed much of Cape Cod, Nantucket and Martha's Vineyard, and the drumlins and eskers of the Boston Harbor area. Because so much of the earth's water was in the form of glacial ice, sea levels were considerably lower. Georges Bank was dry land and connected to the mainland. As the glaciers melted over the ensuing millennia, sea level rose causing inundation and erosion along the shore. As the coast eroded, sand and gravel were redeposited by waves and currents to form the beaches, dunes, and coastal barriers that we now see in Plum Island on the North Shore, Sandy Neck on Cape Cod, and Horseneck Beach in Buzzards Bay. The quiet waters behind the barriers, and in the river valleys flooded by the rising sea waters, provided shelter for the formation of extensive salt marshes and tidal flats. Today some 48,000 acres of salt marsh, 42,000 acres

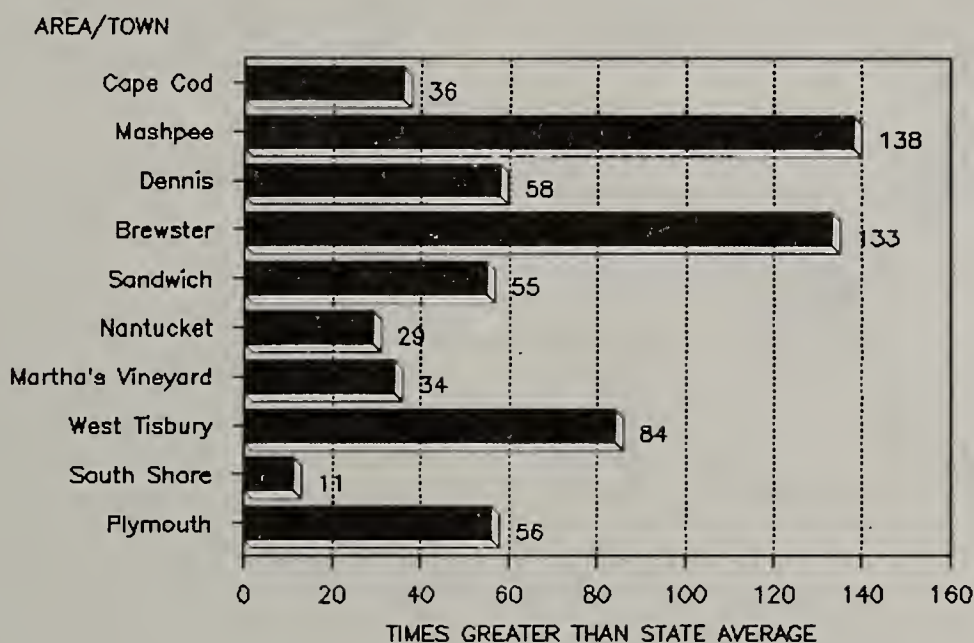
of tidal flats and nearly 19,000 acres of barrier beaches are found along the shores of our Commonwealth.

The coastal environment is one of the most valuable natural and economic resources in Massachusetts. The salt marsh complexes along the shore provide a nutrient source important to the oceanic food chain. Estuaries, salt ponds and shallow embayments also provide nutrients. These water bodies are areas of high "primary productivity" (the conversion by plants of solar energy to chemical energy) and are valuable as spawning and nursery areas for finfish, shellfish and crustaceans. Migratory birds, particularly waterfowl and shorebirds, are also greatly dependent upon the salt marshes, tidal flats and protected waters for feeding, resting, and nesting areas.

In addition to their value as habitat and sources of primary productivity, natural land forms (barrier beaches, dunes, beaches and salt marshes) in the coastal zone provide significant protection from ocean storms, flooding and erosion. Their form and structure dissipate wave action and prevent direct wave attack against inland areas.

For over 350 years, the Massachusetts coast has offered protective shelter, natural ports, and a means of commercial livelihood for generations of Americans. Much of the history and evolution of the United States emanates from Massachusetts' ports of call - Newburyport, Salem, Boston, Plymouth, Provincetown, New Bedford and Nantucket. The protected bays and river mouths have traditionally provided stable waterfront for piers, wharves, docks, warehouses and other facilities. The contributions of ports to the Massachusetts economy is not merely a

# POPULATION GROWTH IN SELECTED COASTAL AREAS 1970 - 1984



phenomenon of times past. Maritime industries now directly employ some 50,000 persons. Traditional port use, however, is not homogenous. Fishing, maritime shipping, marine industries, boat yards, and marinas are all vital port activities, and sometimes must compete for limited resources. A dozen Massachusetts harbors contain water depths of over 20 feet and reasonable access to landside transportation. These are now Designated Port Areas and are protected by regulation for marine industrial use.

Massachusetts' coastal traditions and values live on. Many of our people still live, work and recreate by the sea. According to 1984 census figures, over 34 percent of the state's population lives in coastal communities, an area comprising just over 20 percent of the land mass of the Commonwealth. While the state as a whole averages about 710 persons per square mile, the 78 communities that

front on the ocean or estuaries average over 1,220. Many suburban and rural coastal communities have experienced two-, three- and in some cases almost four-fold increases in population in the years between 1970 and 1984, while figures for the state as a whole have remained almost constant.

This growth, and the attendant increases in industry, commercial facilities and supporting transportation, has come at the expense of open space - forests, farm land and recreational areas. Presently, of the 1,500 miles of shoreline, only 358 are in public ownership. In the latter category, 63 miles are state owned.

Directly and indirectly, the coastal environment is important to the economy of the Commonwealth. About 70 percent of the commercially important fish catch spends a part of its life cycle in New England estuarine waters. This fact is

# Coastal Zone and the Historic Ports

Scale: 0 10 miles



Massachusetts  
Geographic  
Information  
System

Massachusetts Executive Office of Environmental Affairs 1999



particularly significant for traditional fishing ports like Gloucester, Boston and New Bedford, the last being one of the largest fresh-fish ports on the East Coast. Additionally, Massachusetts waters are heavily utilized for sport fishing, boating, swimming and other recreational pursuits.

The coast supports facilities and industries important to the economy of the entire state. Three fourths of all the state's energy supplies enter Massachusetts through an urban port. Eighty percent of all electric generating plants in the state are located along the coast. Well over half of all travel and tourism, a multi-billion dollar industry in Massachusetts, occurs in coastal areas. Commercial fishing, including fresh and frozen fish processing, and the supporting transportation and marketing services, is a one billion dollar per year industry. Landed values of commercial fisheries in 1988 totaled over \$274 million (286 million pounds). Commercial shellfish landings worth nearly \$20 million were also recorded. These figures do not include the vast amount of resources taken by recreational fishermen and shellfishermen.

More than any other single natural resource, the coast has defined and continues to define our self-identity and the view that the rest of the world holds of Massachusetts.

## ATMOSPHERIC RESOURCES

The air mass that we live in is a shared and involuntarily-used resource. Its quality is dependent on the contaminants we emit, natural processes that release materials into it, chemical reactions that occur within it and various physical meteorological effects. We live

in the troposphere, which extends seven miles above the surface of the earth. This ground-level layer only occasionally interacts through thunderstorms and other extreme meteorological conditions with the next layer, the stratosphere, which extends 30 miles above the earth.

All life depends on the air resources for its life energy processes, and plants use such air components as nitrogen and carbon for nourishment if they are present in an appropriate chemical form. The earth's atmospheric resources also serve as a shield, a filter for the sun's rays, and storage, preventing heat from being lost to space.

In addition to the involuntary physical needs of animal and plant life for air and its chemical components, modern society uses air in other ways. Air carries heat to and from our living environment. It is used in processes that generate power, incinerate waste, manufacture products, and heat, dry or coat paper and other materials. It is also used as a place to dispose of waste materials.

Air is the medium through which contaminants transfer most quickly. It is a resource shared by many but controlled by no one. Pollutants emitted to the air are often physically and chemically transformed. As a result, the relationship between emissions and pollutants deposited by rain, snow, fog and dry deposition is unclear and thus makes the atmosphere that much more difficult to protect. Regional interjurisdictional efforts are essential. Air quality strategies must be directed at controlling the source of emissions, yet it is difficult to determine precisely what air quality benefits will result because ultimate air quality depends so heavily on meteorology.

Two of the best processes for temporarily improving air quality are precipitation and air mass movement by the winds. Unfortunately, these are merely ways to transfer environmental contamination, either to another medium or to another jurisdiction.

Some of the atmospheric chemical reactions caused by heat and solar radiation degrade and decompose contaminants to some degree, but generally the materials produced by transformations are also harmful to life. Examples are the formaldehyde created in smog from volatile organic materials, ground level ozone and the acidic sulfate particles that are a major cause of acid deposition.

Massachusetts' air is an ever-moving, ever-changing resource. Prevailing winds are generally from the west. Southwest weather patterns arrive from New York City and Washington DC, and northwesterly from Canada. The air mass carries with it the pollutants that upwind states have introduced in prior days or weeks. As the air masses move with the weather patterns, they take whatever has been emitted into it, transform some contaminants and leave behind what has been deposited on our fields, forests, cities, waterways and lungs.

*Publications and documents used as the basis for information presented in this chapter include the following:*

*"Preliminary National Wetlands Inventory Report on Massachusetts Wetland Acreage", Ralph Tiner, U.S. Fish and Wildlife Service, April 1989. "Massachusetts Forest Resources - A Working Guide to Action", Meriel Moore, Mass. Dept. of Environmental Management. "Classification*

*of Wetlands and Deepwater Habitats of the United States", Cowardin, Carter, Golet and LaRoe, U.S. Fish and Wildlife Service, 1984. "Forest Cover Types of the United States and Canada", F.H. Eyre, Society of American Foresters, 1980. "Cumulative Impact Assessment in Bottomland Hardwood Forests", Gosselink and Lee, U.S. Environmental Protection Agency, 1987.*

## CHAPTER II

### THE CULTURAL ENVIRONMENT - OUR CHANGING LANDSCAPE

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#### A BRIEF LANDSCAPE HISTORY

The nature and extent of human habitation and economic activity are the most important determinants of the quality of the Massachusetts environment. These are the influences which affect our natural resource heritage. There can be no doubt that population, the nature of our economic activities, transportation technology and our patterns of settlement, both current and historic, determine the quality and quantity of natural resources and amenities available for our use and enjoyment.

The first European settlers in New England did not discover a vast forested wilderness unshaped by human culture and influence. Some 11,000 years of Native American habitation modified the landscape in significant ways. Large areas of land had been cleared, agriculture was well developed and widespread, forests were managed to make hunting and gathering more efficient, and trails crossing the landscape showed that travel between settlements was frequent and widespread. Virtually all arable lands from the Berkshire hills east showed clear signs of native american agriculture. The corn, beans and squash grown by these first Americans became the staple crops which European settlers depended on for nearly two hundred years. The very name of this Commonwealth, Massachusetts, was taken from the tribe of Native Americans, the people of the Great Blue Hills, who lived around the bay which was later named after them as well.

The early English colonists and those who followed over the next 200 years first developed the land in those same areas as the Native Americans who preceded them. In the subsistence agriculture on which the early settlers depended, inland farms might range from 100 to 200 acres in size. While only a small portion of that would be tilled, perhaps a dozen acres, a third was kept in pasture and the rest in woodland. Through the Revolutionary and Federalist periods in Massachusetts, more and more land was cleared to support the agricultural needs of a growing population. By the end of the first quarter of the 19th century, the Commonwealth was only about 30 percent forested.

Early cottage industries and maritime activities became factors behind a unique Massachusetts cultural identity. Yet, it was the role of Massachusetts coastal communities as centers of commerce between Europe and the New World that had perhaps the greatest long-term influence in determining the landscape as we see it today. With commerce came capital and exposure to technology, which together fueled the birth of the American Industrial Revolution beginning in the early 19th century.

Both the Industrial Revolution, which sparked the move toward rapid urbanization, and the advent of the railroad made subsistence agriculture unnecessary and most market agriculture eventually unprofitable. Over the next century mill towns and industrial cities

grew up along rivers which powered the mills and factories and caused a major shift in settlement patterns and the distribution of population. The industrial revolution drew people from scratching a living out of poor, rocky soils into industrial cities and mill towns and allowed for the reforestation of much of the Commonwealth. The stone walls and foundations found in now wooded areas throughout the state are silent testimony to a land use pattern that predominated for nearly 200 years. Farms and fields lay fallow and the forests regained their role as the predominant land cover of the Commonwealth. Industry dammed the rivers, altered and eliminated many native fisheries and began to discharge the wastes that became our present water pollution and hazardous waste legacies. As the result of large concentrations of population, the Boston metropolitan area embarked on a hundred-year quest for sufficient quantities of pure water, which altered the landscape of the eastern two thirds of the state.

The movement of population from the countryside into the cities began to reverse as early as the 1890s with the advent of streetcars and septic systems and accelerated in the 1920s as automobiles became available and public transportation systems expanded. In the 1950s, state and federal highways provided the newest transportation network and spelled the decline of the railroads and intercity trolley systems.

Suburbanization had advanced considerably as Massachusetts led the way into the start of the Post-industrial period in the 1950s. At the same time, the Massachusetts economy moved toward dependence on services and high technology. This change subjected a once-neglected countryside to increasing

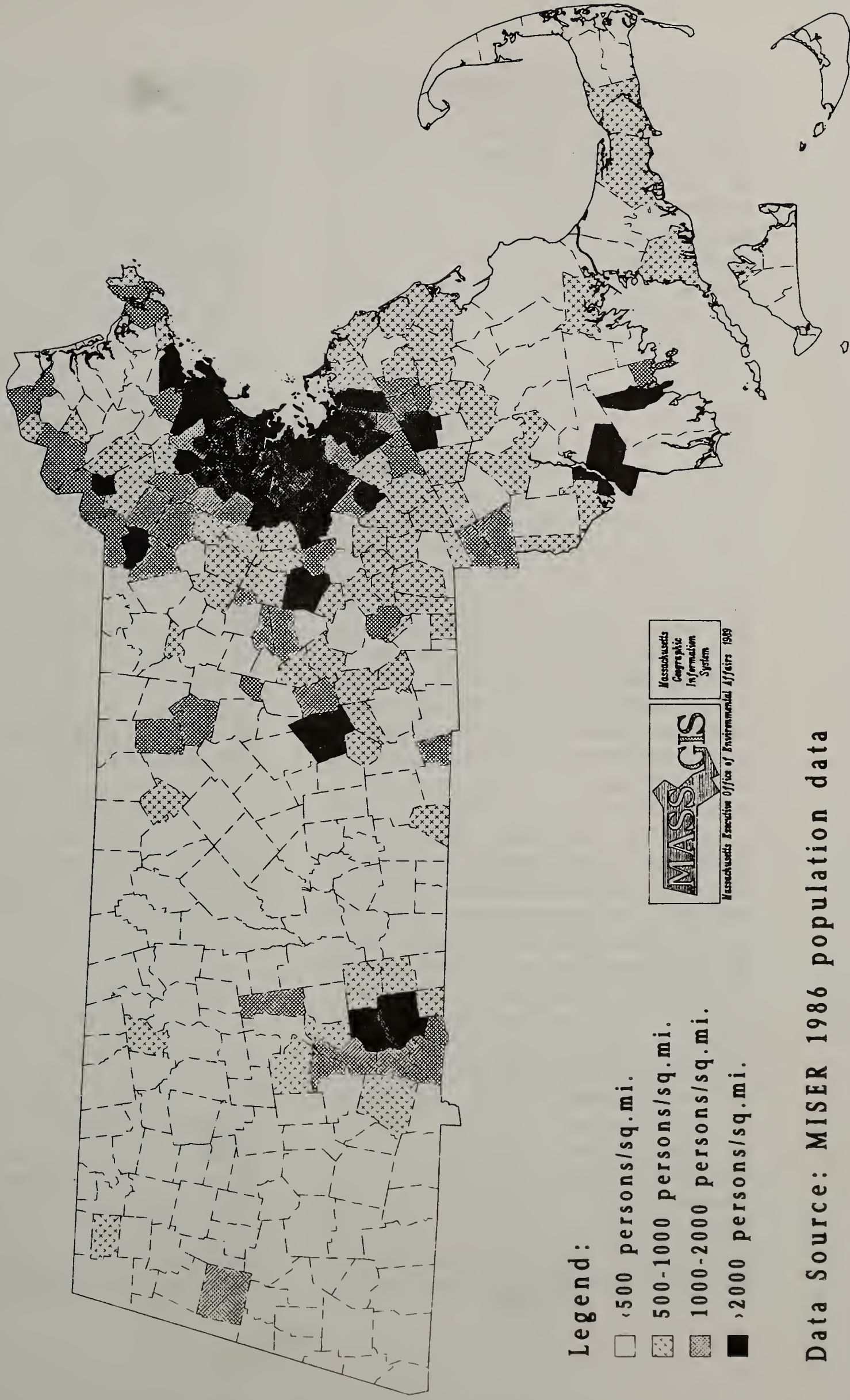
development pressures as industry began to follow the migration of population out of the cities and into predominantly rural and agricultural areas. Retail shopping centers and malls followed in keeping with the trend away from urban areas and all these influences contributed to the rapid decline of our cities. Suburbanization consumed large tracts of previously undeveloped land. Prosperity brought the ability to develop the landscape at an unprecedented scale. The trend toward development of the land for residential purposes continues unabated to this day even though population growth is at a virtual standstill.

The Massachusetts landscape that we see today has some of each of these periods in it. Farms, fields and scenic rivers provide diversity and beauty. Many small New England village centers grace the countryside. Many mill towns and industrial cities have been revitalized, finding renewed purpose and economic prosperity. A revival of many older urban areas occurred during the 1970s and '80s as people rediscovered the value and charm of existing older buildings and as state and local governments targeted these areas for revitalization. The economy remains strong enough that we are blessed with the opportunity to shape our environment not merely through reaction to economic opportunity but also according to sound ecological principles that will preserve a quality of life that is the very basis of our Massachusetts heritage.

## THE DEMOGRAPHICS OF THE COMMONWEALTH

Massachusetts had a 1980 population of 5,737,093, which placed it as the 13th most populous state in the nation. Population for 1987 was estimated

# Population Density By Town in Massachusetts



at 5,857,479 (CACI, Arlington, VA), an increase of 2.1 percent. With a total area of 8,257 square miles it is the sixth smallest state and currently ranks third in the nation in population density with 710 persons per square mile. There are ten cities with populations over 80,000, only three of them over 100,000. In 1980, 57 percent of Massachusetts communities had populations under 10,000 and 36 percent under 5,000.

These contrasting statistics help to illustrate the reality of population distribution in Massachusetts. Contrary to the popular view outside of Massachusetts of an essentially urban state, the Commonwealth is primarily made up of small communities with several larger cities near the coast, one in the central part of the state and another in the southern Connecticut River Valley. Medium sized mill towns built during the industrial revolution add to the diversity of the Massachusetts landscape. Numerous rural communities in the far western and central portions of the state preserve its rural character.

But, since the mid 1950s, Massachusetts has become an increasingly suburban state with residential land use remaining the fastest growing of all land use categories. Massachusetts as a whole has so far managed to avoid the degree of suburban homogeneity that would eliminate our landscape and cultural diversity. Yet, without change in our development patterns, there is little hope that we will escape it in the long run.

Population density varies dramatically across the Commonwealth, illustrating again the diversity that many of us take for granted and that others fail to recognize if they do not stray beyond the Boston metropolitan area. Suffolk

County is the most densely populated with 10,883 persons per square mile in 1980. At the other extreme Dukes, Franklin, Nantucket and Berkshire Counties have population densities of only 81, 89, 104 and 153 persons per square mile respectively. Counties dominated by suburban land use patterns such as Norfolk, Middlesex and Essex with population densities of 1,485, 1,615 and 1,231 respectively hold the middle ground.

If one considers the facts that Massachusetts is nearly 64 percent forested, that 22 percent of our communities are on the coast and that there are 2,871 lakes and ponds in the Commonwealth and 2,000 named rivers and streams flowing for over 10,700 miles, it becomes apparent that we live under unusual circumstances. Massachusetts residents enjoy a robust economic lifestyle set within a predominantly natural landscape.

## **POLITICAL STRUCTURE AND LAND USE REGULATION**

There are 351 communities in Massachusetts. Thirty-nine of those have adopted a city form of government and the remaining 312 adhere to some form of town meeting government. Most of the Commonwealth's fourteen counties do not play a strong role in governance and have no legislative powers. There are thirteen regional planning agencies established to plan for the economic and social growth of the regions they represent and to assist their member communities in local planning efforts. All but one Massachusetts town regulate land use through zoning. Planning agencies or boards exist in 348 communities and nearly 300 cities and towns have developed master plans at some time, though it is certain that many are now

outdated.

Just as important as the political subdivisions of the Commonwealth is the home rule tradition which has shaped the division of power and responsibility. In home rule states such as Massachusetts, all governmental powers not specifically appropriated to the state are local. This strong home rule tradition in Massachusetts is manifest in the independent spirit common to its towns and the frequent reluctance of some communities to accept limitations even when they would promote a common good. The home rule tradition has significantly affected efforts within the Commonwealth to manage growth.

The Zoning Enabling Act of 1954 established the parameters for zoning bylaws as we know them today. The current Zoning Act was passed in 1975 and increased the regulatory opportunities and flexibility available to local municipalities to manage their growth. During the early 1960s, regional planning agencies were established and districts identified to ensure that all municipalities were represented. However, the regional planning agencies were given only an advisory role. Local planning boards and town meetings maintain responsibility for land use regulation.

In 1986, legislation was passed that called for counties to reassess their roles and to develop new charters. Charter commissions were elected in most counties and spent 18 months reviewing their charters. Several of these commissions, especially in rural counties, considered a strong county role in land use planning. With a few exceptions the commissions were unable to develop the support needed to develop such regional land use review mechanisms. Barnstable County has

moved forward with legislation mandating the formation of a Cape Cod Commission; passage was secured in the waning moments of the 1989 Legislature.

Another problem facing local planning efforts is coordination among town boards with overlapping responsibilities which affect growth management. For example, in Massachusetts, selectmen oversee maintenance and expansion of town roads, conservation commissions implement wetlands regulations and develop open space plans, and local boards of health establish regulations influencing where septic systems can be placed or determining if certain developments can tie into water and sewer systems.

Implementing new growth management regulations is an especially difficult task in Massachusetts due to the length of time needed to effect change. A simple, straight-forward modification to a zoning bylaw can take an average of six to nine months while significant changes can easily take two to three years. Not only do local planning boards have to reach their own consensus about bylaw changes, they then have to build a consensus on the need for change within the community in order to obtain a two-thirds vote at town meeting. Furthermore, the "grandfathering" provision of the Zoning Act gives developers eight years after a bylaw change to build in accordance with subdivision plans submitted prior to its effective date. The problem of effectively implementing growth management options under these circumstances should be apparent.

In 1987, the Massachusetts Legislature established the Special Commission on Growth and Change. It

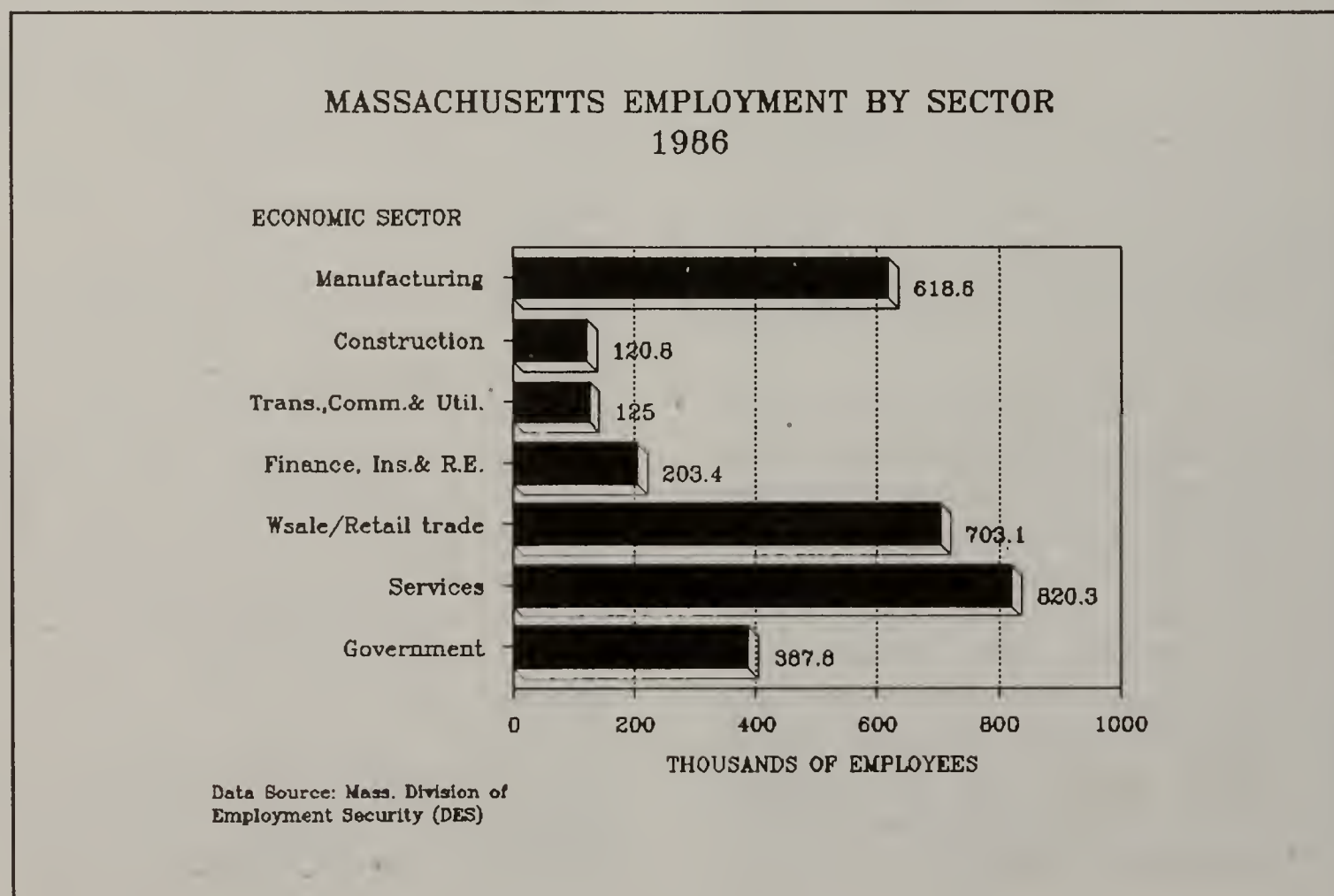
was charged with assessing patterns of residential, commercial, industrial and recreational development throughout the Commonwealth and examining the effect of these land uses on natural resources, affordable housing, employment, infrastructure, and local governance. The Commission set out to identify the problems in these areas and to propose workable long-term solutions to address public concerns. Their final report, released in January 1990, presented recommendations toward a planning process for the future of the Commonwealth.

## AN ECONOMIC PROFILE

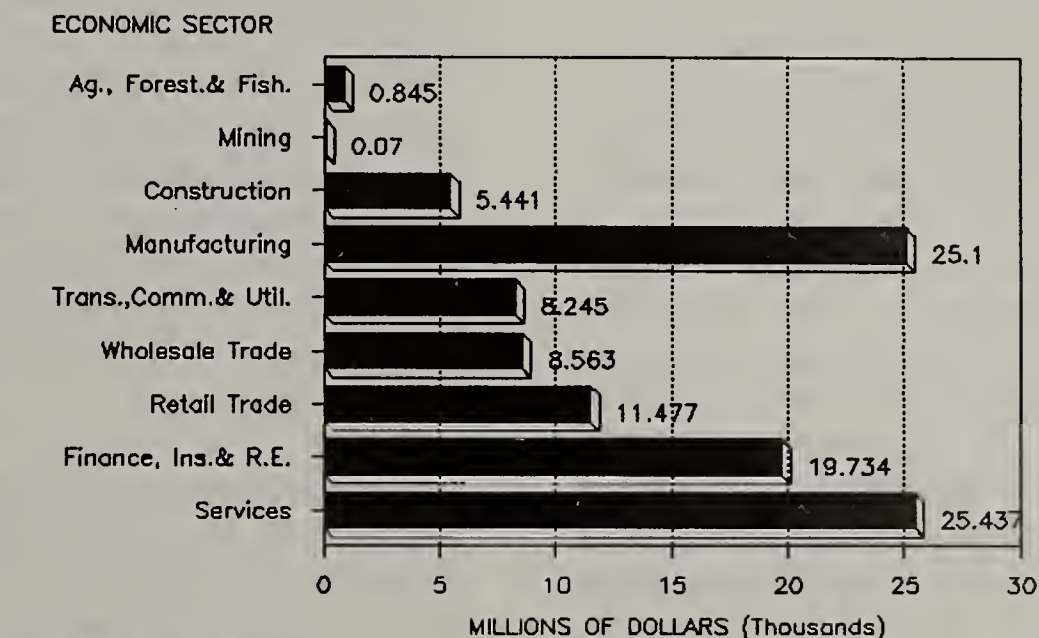
Information concerning the Massachusetts economy is important in evaluating the stresses we place on our natural environment. For the past 40 years the Massachusetts economy has

been in a state of transition, with traditional manufacturing in decline and the service sectors of the economy growing steadily. This is apparent from data on employment by sector. Data for 1986 show 820,000 persons employed in the service sector, 703,100 in wholesale and retail trade and 618,600 employed in manufacturing. Manufacturing, however, remains vital to our economic well-being. In 1986, with a total Gross State Product (GSP) of over \$115 billion, manufacturing at \$25.1 billion ranked a close second to the service economy at \$25.4 billion.

Many of these economic activities can place environmental resources at risk. The production of durable goods such as computers and other electronic equipment, machinery, instruments and tools, a \$12.4 billion portion of GSP, generates considerable toxic waste which must be kept from entering our surface and groundwater resources or otherwise



## MASSACHUSETTS GROSS STATE PRODUCT COMPARISON OF ECONOMIC SECTORS - 1986



Data Source: U.S. Department of Commerce

threatening public health and the environment. Non-durable goods produced in Massachusetts, including textiles, apparel, rubber and plastic products, chemicals and related products and printed materials, generate a significant waste stream which must be carefully managed to avoid environmental degradation and impacts on public health. Even within the service economy for example, the largest sector - health services - with a \$6.9 billion share of GSP, is a significant generator of low-level radioactive wastes.

The relative size of the nine principle sectors of private industry in Massachusetts is illustrated above. It is worth noting that, as development pressure has increased over the years in the Commonwealth, the value of the real estate market, at \$14.5 billion in 1986, is the single largest sub-sector of the GSP as tracked by the federal government. The

real estate market has grown 212 percent since 1980 and 409 percent since 1970 in current dollar values.

The portion of GSP generated by agriculture, agricultural services, forestry and fisheries was \$845 million in 1986 dollars. Farm income accounted for \$360 million of that total. The production of lumber, wood products, furniture and related wood fixtures represented another \$442 million share of 1986 GSP.

What is difficult to account for through the examination of GSP figures is the extent to which other sectors of the Massachusetts economy depend either directly or indirectly on our natural resources base for their vitality. Tourism is a prime example. Tourist dollars are significant contributors to the hotel, lodging and restaurant industries as well as retail trade and recreational services. Without the natural environment that

makes Massachusetts a desirable tourist destination, it is certain that these industries would not enjoy the strength that they do.

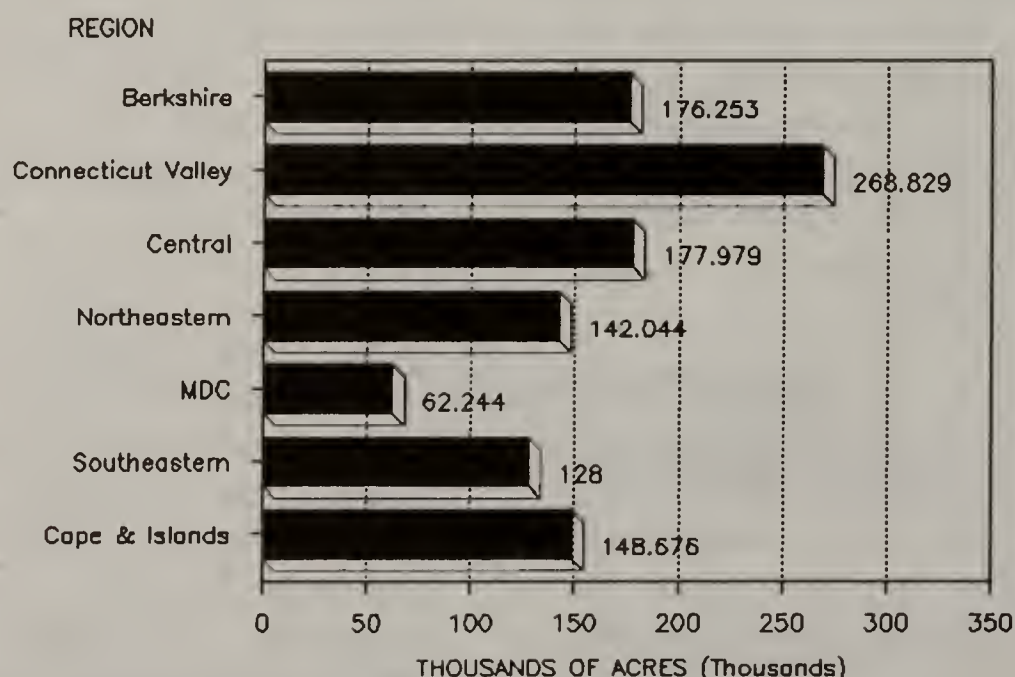
A strong economy and environmental quality need not be at odds with one another. They are in many ways inseparable. The high quality of life that Massachusetts residents enjoy is based upon these very factors - good economic opportunity in close proximity to a highly desirable natural environment. Studies that show only the costs of pollution control often neglect to evaluate the ways in which we value and realize the benefits of improved environmental quality. Environmental quality is not a good that we can generally purchase in the market place. Yet diminished environmental quality devalues our lifestyles in many significant ways.

## OUR USE OF NATURAL RESOURCES

Many segments of the Massachusetts economy make significant use of our natural resources even though less than 1.5 percent of the state economy is directly dependent on natural resource input in the conventional sense. We have no mining of metals or fossil fuel energy resources; commercial forestry is limited; and the vast majority of the Massachusetts work force produces goods and services that require little or no direct natural resource inputs.

Our non-consumptive use of natural resources fuels many segments of the economy, directly and indirectly. Tourism depends heavily on our tremendous wealth of natural and cultural resources. Agriculture and the commercial fishing industry in Massachusetts remain very important to local economies and to maintaining the character of our rural

RECREATIONAL OPEN SPACE  
TOTAL ACRES BY REGION



Data Source: 1988-1992 SCORP

and coastal communities and hence supporting other economic activities. The demand for recreational opportunities and services assumes adequate access to open water, the sea, forests and mountains. Hunting and fishing depend upon protection of habitat, high quality surface water and open access. Industry itself depends upon both surface and groundwater to play important roles in industrial processes and the removal of wastes. The Massachusetts economy as a whole depends on a high quality of life to attract and retain a highly-skilled and mobile work force. In spite of characterizations of Massachusetts as an industrial urbanized state, its natural resources remain the very lifeblood of the economy.

The demand for outdoor recreational opportunities in Massachusetts is high. Data for 1985 from the Massachusetts Division of Tourism show that some 22.6 million tourists and travelers visited our state and spent \$6.2 billion. In-state demand for four different types of outdoor recreation was estimated at 4,442,278 activity days in the 1988-1992 Statewide Comprehensive Outdoor Recreation Plan (SCORP). This estimate includes demand for resource-based activities such as camping, hiking and picnicking, sports and field-based recreation and water-based and winter-based recreation.

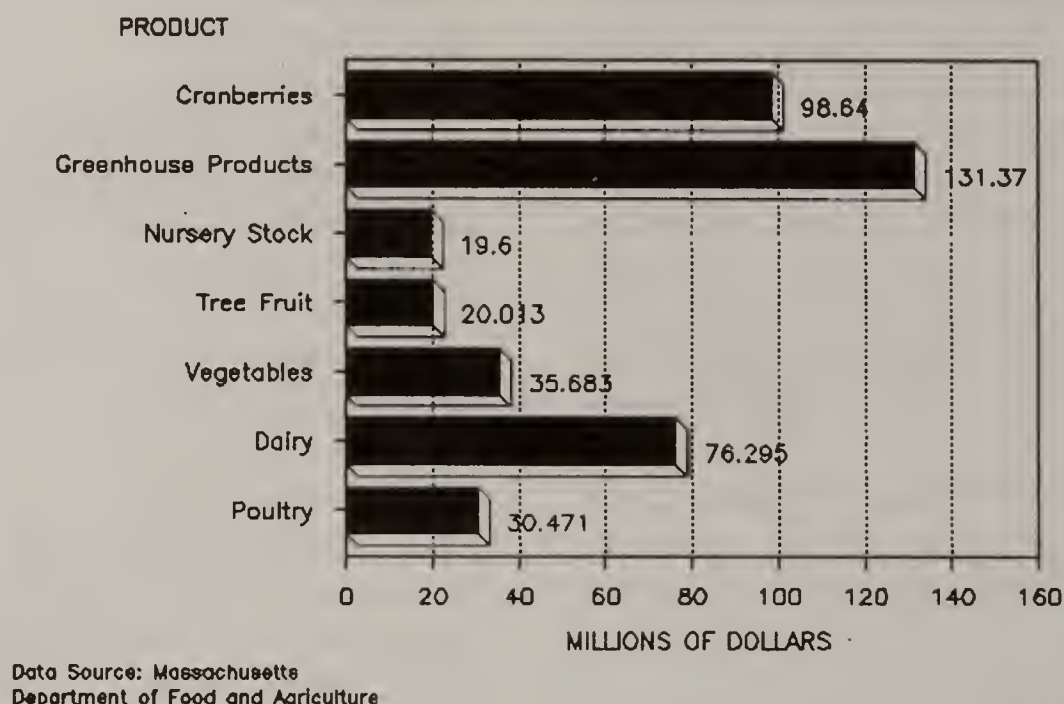
While the supply of recreational opportunities is adequate to meet most of these needs, the supply of certain opportunities such as boating, golfing and tennis does not meet the demand. In addition, opportunities for the desired types of recreation frequently do not exist within the distance that residents are willing to travel.

The 1988-1992 SCORP document also shows the existence of over 1.1 million acres of recreational land and facilities representing 10,963 sites in the Commonwealth under state, local, federal and private control.

The Massachusetts forest resource is used in a variety of important economic activities which include timber and fuel wood production, recreation, hunting and fishing, and the augmentation of public water supplies. With specific reference to the harvesting of the forest, it is estimated that 240 million board feet of timber are processed annually with a stumpage value of \$12 million. The value added by the Massachusetts forest products industry is estimated to exceed \$1.1 billion. The 1,046 Massachusetts companies in the forest products industry employ over 38,000 people with an annual payroll of \$697 million. Approximately one million cords of fuel wood are burned each year in Massachusetts, a volume equal to 150 million gallons of home heating oil worth \$187.5 million at \$1.25 per gallon.

Agricultural activity in Massachusetts was estimated at \$400 million in 1987. The "green" industry, at \$131,370,000, is the leading agricultural industry and ornamentals represent the largest share, 80 percent of that total. Cranberries are the second leading agricultural crop at \$98,640,000 in 1987. Massachusetts produces 48 percent of the U.S. crop and 80 percent of the total of 11,709 acres are located in Plymouth County. Dairy products are the third leading agricultural commodity with a 1987 value of \$76,295,000. In 1987 there were 545 dairy herds found in 169 communities. The five counties in Western Massachusetts account for 75 percent of milk production while the town of Westport in Bristol County is the leading

## MASSACHUSETTS AGRICULTURAL STATISTICS MAJOR PRODUCTS - 1987



dairy community in the Commonwealth. Vegetable production ranks fourth at a value of \$35,683,000. While the three Connecticut River Counties lead in the number of acres devoted to vegetable production with 7,000, another 8,000 acres are scattered through Bristol, Essex, Middlesex and parts of Worcester and Plymouth Counties.

Poultry, which includes fresh eggs, poultry breeding and fresh turkey production, ranked fifth at \$30,471,000 in 1987. There are 63 farms distributed fairly evenly across the state. Tree fruit (\$20,013,000) and nursery stock (\$19,600,000) ranked sixth and seventh respectively. Worcester County is by far the leading producer of orchard fruit and the counties in Eastern Massachusetts lead in production of nursery stock. The remaining agricultural products of Massachusetts include Christmas trees, hay, maple syrup, wine, honey, small fruit,

sprouts, tobacco, beef and veal.

Hunting and fishing rely on our natural resource base both for the harvest of fish and game and for the habitat upon which their existence depends. An average of 235,400 fishing and 133,350 hunting licenses per year were issued between 1982 and 1986. Based on those figures and average 1985 annual expenditures of \$643 per fisherman and \$531 per hunter, the Massachusetts economy realizes nearly \$225 million each year through these activities. It is furthermore estimated that in 1985 \$333 million was spent on activities related to non-consumptive wildlife recreation such as birdwatching.

## LAND USE CHANGE IN MASSACHUSETTS

Massachusetts is fortunate to have been the subject of three very detailed

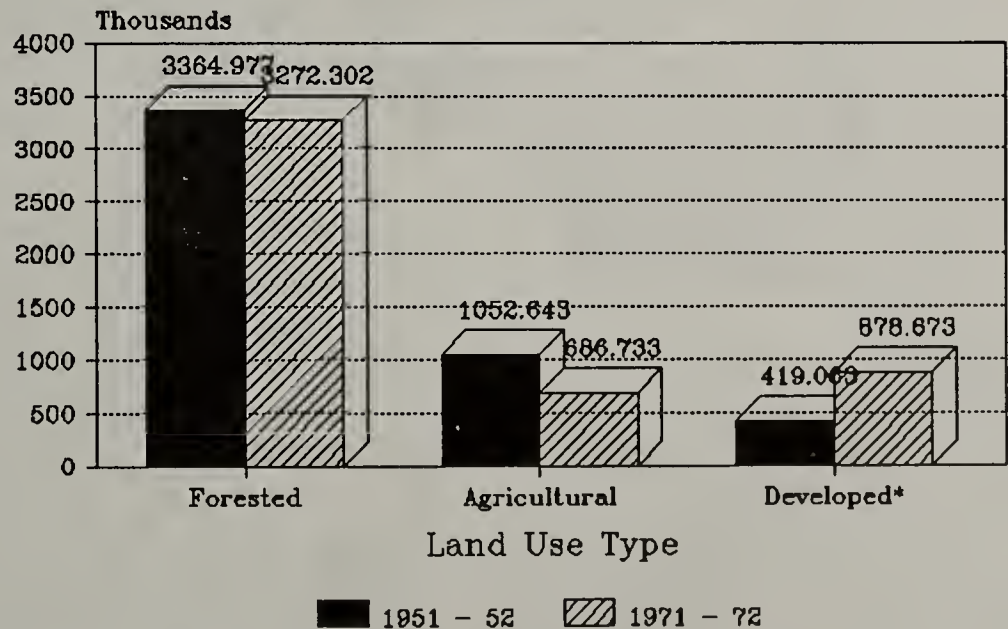
land use studies conducted during 1951-52, 1971-72 and 1984-85. These studies, all led by Professor William MacConnell of the University of Massachusetts at Amherst, provide a wealth of data for the period of time when land use change in the Commonwealth has been the most rapid and dramatic.

In 1951-52 64.7 percent of the Commonwealth was forested, 20.2 percent in agriculture, 8.1 percent listed as residential, commercial, industrial or other and 7 percent as wetlands and open water. (None of these studies included forested wetlands which are estimated at 56 percent of all wetlands in Massachusetts. Thus, none of these studies can be viewed as estimating wetlands loss.) Twenty years later the amount of forested land had not changed significantly; 62.9 percent was still covered by forest. Agricultural land on the other hand was assessed at only 13.2

percent of statewide land use, a 34.7 percent decrease. Residential, commercial, industrial and other classifications for developed lands had increased to 16.9 percent, a 108.6 percent increase.

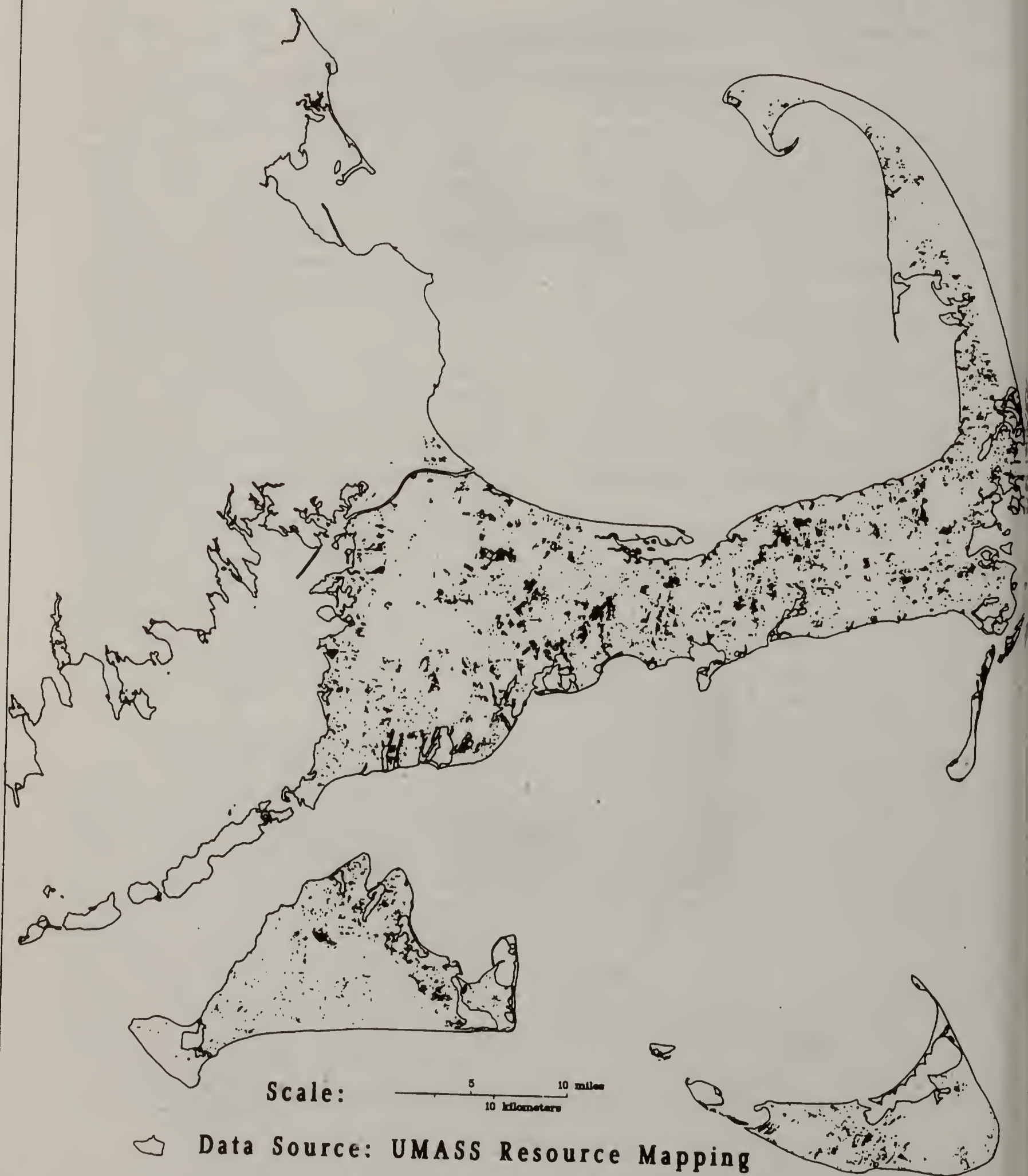
The study of 1984-85 land use change is still under way. Data for five counties are essentially complete and for the remaining eight counties, while all the photo interpretation is complete, the data for 72 communities have yet to be automated and analyzed. The 1984-85 information for the five completed counties of Barnstable, Franklin, Hampden, Hampshire and Norfolk has been analyzed and an assessment of land use change made for the purposes of this report. Much of the detailed land use change statistics is presented here in graphic form. For the five-county study area as a whole, some 9.3 percent of forested lands were converted to other uses during the 34 year period from 1951

### LAND USE IN MASSACHUSETTS

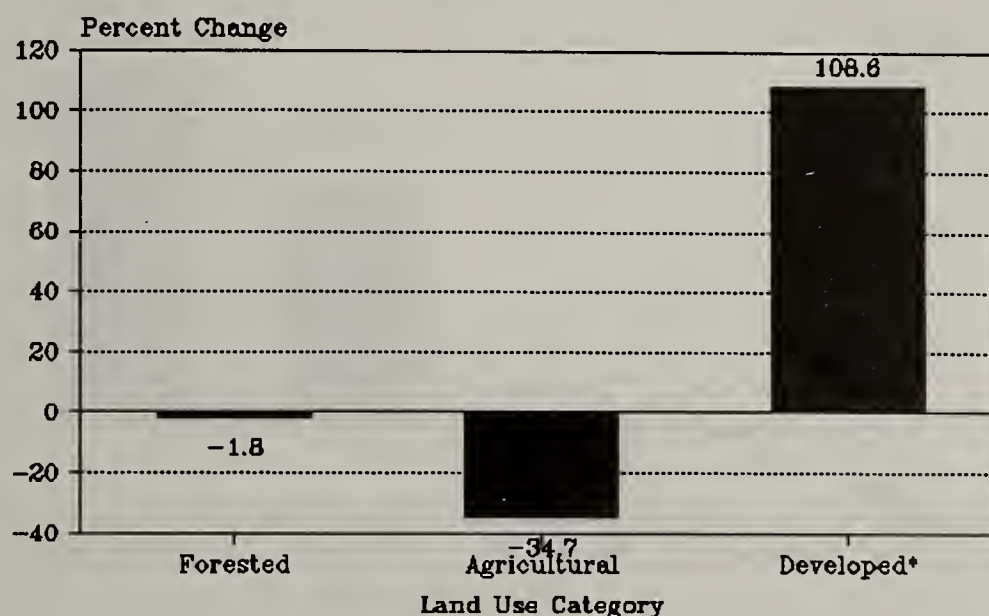


Data Source: Massachusetts Map Down  
Series: Univ. of Mass. \*Includes  
Residential, Commercial, Industrial.

# Land Use Change on Cape Cod, 1971-1984



# LAND USE CHANGE IN MASSACHUSETTS 1951-52 TO 1971-72



Data Source: Massachusetts Map Down  
Series: Univ. of Mass. \*Includes  
Residential, Commercial, Industrial

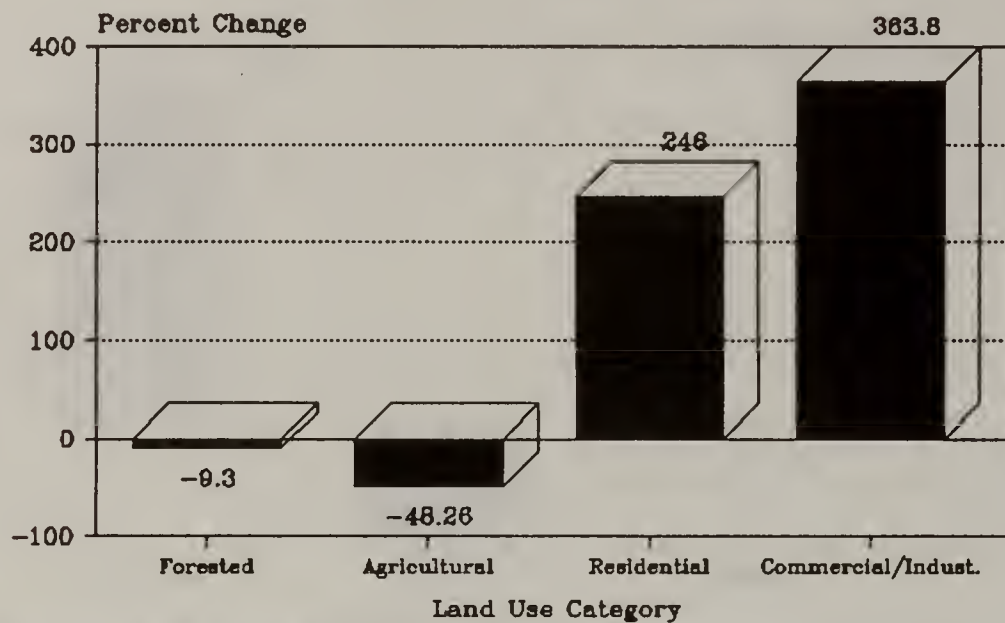
to 1985. Agricultural lands have clearly been the most significantly affected, with a 48.3 percent decrease over the study period. Residential land use increased by 246 percent and commercial/industrial use by 363.8 percent. These counties are likely to be good indicators of the extent and nature of land use changes in other sections of the state as well.

If these numbers do not bring home the reality of the extent of land use change occurring in Massachusetts, consider the following. During the 34-year period from 1951 to 1985, with the exception of agricultural use, more land was converted from undeveloped to developed status than in the entire preceding 330 years since Europeans first settled in Massachusetts. Within the five-county study area, 64 percent of all development occurred during this 34-year period, a rate 17 times greater than in the years prior to 1951. On Cape Cod,

during the period from 1951 to 1984, 26.2 percent of a delicate forest ecosystem was converted to residential use, an area representing 17.3 percent of the entire land mass of Cape Cod. From 1971 to 1984 alone an area of forest land roughly equal to the size of Chatham or Harwich was developed for residential use. In the Connecticut River Valley an area of agricultural land nearly twice the size of Suffolk County has been lost to development since 1951.

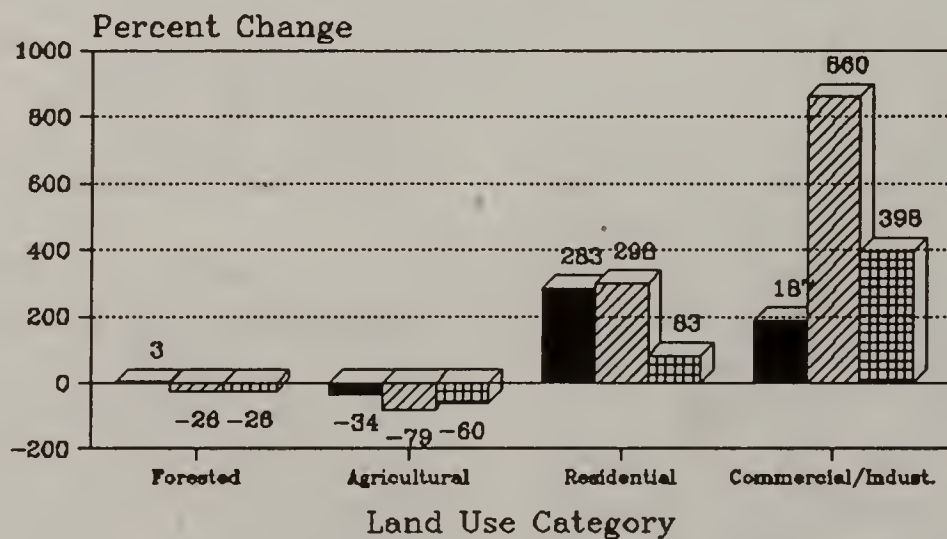
Massachusetts is threatened by over-development and inadequate attention has been paid to preserving cultural and landscape diversity. Since many of our best lands are the most easily developed, they are the first to go. If the rate at which agricultural land is being converted to other purposes does not change, all agricultural lands would be lost within the next 34 years. The threat to natural

# LAND USE CHANGE 1951-52 TO 1984-85 FIVE COUNTY STUDY AREA\*



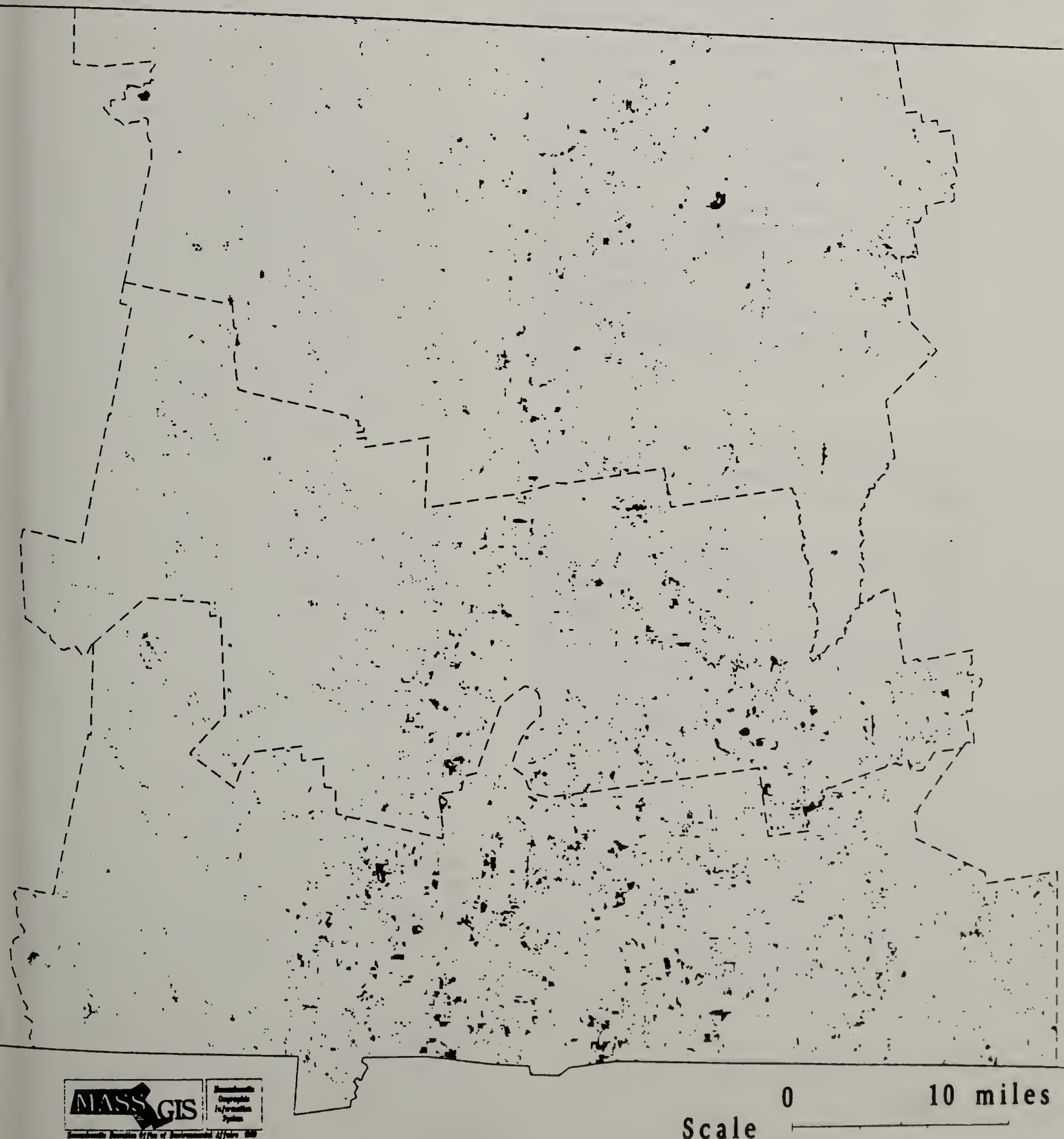
Data Source: Massachusetts Map Down  
Series & MassGIS. \*Barnstable, Frank-  
lin, Hampden, Hampshire, Norfolk

## 33 YEARS OF LAND USE CHANGE A COMPARISON OF THREE REGIONS



■ Connecticut Valley    ▨ Cape Cod    ▤ Norfolk County

# Land Use Change in Hampden, Hampshire and Franklin Counties from 1971-1985



Data Source: UMASS Resource Mapping from 1985 photos

resources which this rate and extent of development creates is immense and dangerous.

The residents of the Commonwealth have shown their concern over this issue in many different ways. Local communities are turning to building moratoria and other drastic measures in attempts to slow or temporarily halt the rapid pace of growth. The Special Legislative Commission on Growth and Change recently suggested that sweeping changes in the ways that we plan and regulate land use may be necessary to stem this tide. The alternative is to pass on to our children and grandchildren a homogeneous suburban landscape and all the environmental and social problems that lack of planning and effective growth management create.

*Publications and documents used as the basis for information presented in this chapter include the following:*

*"Historical Atlas of Massachusetts", Tager and Wilkie, University of Massachusetts Press, Spring 1990. "Remote Sensing 20 Years of Change in Massachusetts", W. MacConnell, Mass. Agricultural Experiment Station, 1975. "For Our Common Good", Klar, Smith and Warnick, Mass. Dept. of Environmental Management, 1988.*

## CHAPTER III

### THREATS TO ENVIRONMENTAL QUALITY

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#### AIR POLLUTION

The Commonwealth's air resources are threatened by many sources of pollution, stationary and mobile, within the state and from neighboring states. Air pollution causes a multitude of environmental and public health and welfare problems. Air pollution affects not only the atmosphere itself, but also those other resources on which the pollution emitted into the atmosphere ultimately settles, such as vegetation or lakes, streams and rivers. This section of the report addresses air pollution in general as well as some specific air pollution problems such as acid rain and global climate change.

Since the Industrial Revolution and the development of the internal combustion engine, society has been emitting into the atmosphere a variety of materials in ever greater quantities. Individually or in combination with other chemicals and with natural meteorological processes, these contaminate the atmosphere and throw natural chemical cycles out of balance. When levels of these contaminants reach a concentration and duration that cause a nuisance, are injurious or potentially injurious to human or animal life, vegetation or property, or unreasonably interfere with the comfortable enjoyment of life and property or the conduct of business, a condition of air pollution exists.

There are literally thousands of different types of chemicals emitted into the atmosphere in Massachusetts every

day. Air contaminants fall into two main categories, combustion emissions and evaporative emissions. Combustion emissions are the best understood air contaminants and have been of concern in the Commonwealth since before 1910 when the Boston Smoke District was established. Oil and coal boilers emit fuel impurities such as sulfur and particulates (including many metals) in their ash, and gases such as carbon monoxide, sulfur dioxide and nitrogen oxides. These gases are also produced in vast quantities by the internal combustion engines that drive most of our transportation systems.

The other major category of contaminants is the organic materials that evaporate during various industrial processes and other types of widespread activities. These chemicals are often derived or synthesized from petroleum products and are found in such materials as coatings and paints, cleaning agents, and organic products like adhesives and sealants. While the entire group of volatile organic compounds (VOCs) is considered an air pollutant, many individual chemical species in the group, such as benzene and some CFCs and pesticides, also have specific toxic or damaging physical properties. Industrial processes contribute about 10-20 percent of the statewide VOC emissions and the remainder comes from a variety of sources including household and business use of solvents and the refueling of trucks and cars.

There are 5,500 stationary (or point)

million to 160 million pounds (12 to 80 thousand tons) of sulfur dioxide each year.

There are 3.5 million automobiles in the Commonwealth, more than one car for every two people. In 1987, 2.4 billion gallons of gasoline were sold in Massachusetts. In 1985, those cars traveled a total of 105,270,500 miles on Massachusetts roads, and emitted 1.7 million tons of pollutants. Given these statistics, it is easy to see why the Commonwealth's air is polluted.

The other source of air pollution within Massachusetts that cannot be overlooked is other states. Contaminated air from upwind states travels sometimes hundreds of miles to register on Massachusetts pollution monitors. Out-of-state contribution can be critical to any state's ability to attain a prescribed air pollution standard. From the Massachusetts acid deposition modeling research, it is evident that less than one third, and perhaps less than 10 percent, of the acidic pollutants in the Commonwealth is contributed by Massachusetts sources. Recent regional modelling exercises confirm that emissions from one state react to become unacceptable levels of ozone in states downwind.

### Resources Affected

The most obvious effect of air pollution is visible impairment of the atmosphere; a plume of particulate matter from a smokestack, exhaust from an automobile, clouds of black smoke as

approaching ground with a

Air pollution human health carbon monoxide other toxic chemicals human health Ambient Air to protect the portions of pollutants, hazardous and means that high risk. Some people, elderly, respiratory illness indoors on levels venture

Air pollution vegetation, in such as forests as agricultural of acid pollution section on Acid

### Control Measures

Massachusetts from sources planning process development regulatory control modified source submit a plan Environmental demonstrates Available Control will not cause pollution. No

until the state has approved its plan. Approvals also set specific facility requirements such as stack testing when the source begins to operate or necessary improvements when an existing source does not comply with the regulations.

Effective control relies on monitoring, periodic reporting from various sources of air pollution, inspections and enforcement action when necessary. An inspection and maintenance program for automobiles is run at local service stations in conjunction with the Registry of Motor Vehicles to ensure that vehicle emission controls are operating properly and within legal limits.

In the last decade, existing industrial facilities have been required to retrofit Reasonably Available Control Technology for processes that emit organics that contribute to ground-level ozone. This requirement was adopted as a result of Massachusetts' failure to meet the National Ambient Air Quality Standard (NAAQS, established under the Federal Clean Air Act) for ozone. Other recent ozone control efforts include the reduction of evaporative emissions of gasoline. In the past three years regulations have been adopted to reduce the amount of evaporative emissions that escape from distributing gasoline and fueling of vehicles, as well as regulations that restrict the volatility of gasoline that can be sold within the state during the summer, when ozone levels are at their highest. Recent regulations require plans from the largest sulfur dioxide sources within the state to reduce emissions that contribute to the problem of acid rain.

Air quality could be further improved if automobile manufacturers were required to make cars that are cleaner, for example, by adopting more stringent tailpipe standards nationwide. Increased

emphasis on developing alternatives to the automobile and on restricting its use can also be effective control strategies.

New materials that rely less heavily on VOCs can be developed. Water-based solvents can replace VOC-based solvents. Widely used consumer products, such as paints and household cleaners, should be improved so that harmful chemicals are not released each time someone paints a house or cleans a kitchen counter.

Many controls must be interstate efforts. For example, the coalition of northeastern state air directors (Northeast States Coordinated Air Use Management) is already working together to pass gasoline volatility regulations and to push for acid deposition control programs. Regional efforts are necessary for two reasons. First, the air resource is regional, national and international. Second, some of the strategies that affect national markets can only be effective if a significant portion of the market, generally a group of states, is willing to back them. It would be difficult for Massachusetts to be effective in restricting the kinds of automobiles contributing to air pollution if New Hampshire and Connecticut were not also to do so. Similarly, only regionwide efforts to reduce gasoline volatility, such as last year's agreement among the Northeastern states, will be successful because of the regional nature of the gasoline market.

## ACID DEPOSITION

When fossil fuels, primarily coal, oil and gasoline, are burned they emit pollutants that are chemically transformed into acid in the atmosphere. Sulfur dioxide, nitrogen oxides and volatile organic compounds (VOCs) are the three

main groups of chemical precursors involved in producing acids that are later redeposited on the earth's surface.

Acid deposition is a more comprehensive term than acid rain, as acidity derived from man-made sources is redeposited through other means besides rain. The two principal means are wet and dry deposition. Wet deposition includes acidic rain, snow, sleet, mist and fog. Dry deposition includes particulates of sulfate and nitrates and gases of sulfur dioxide and nitrogen dioxide. Acidic pollutants can be transported long distances until they fall as wet deposition, but the quantity of dry deposition declines rapidly as the distance from the source increases.

Dry deposition contributes as much as 30 - 50 percent of total deposition, though it is generally easier to measure wet deposition amounts. Although wet deposition is a more acute delivery mechanism, dry deposition operates all the time.

Once acidic pollutants are deposited they start to break down into various components. Of greatest concern are sulfuric and nitric acids which dissociate in water into hydrogen ions and sulfate and nitrate ions. The dissociation of these strong acids results in increased acidification with its many effects on aquatic and terrestrial ecosystems.

On every acre of Massachusetts .3 to .7 pounds of hydrogen ions, 16.2 to 27.5 pounds of sulfate and 8 to 22 pounds of nitrate fall each year as the result of acid deposition. The average annual pH (the measure of acidity wherein high values represent low acidity and low values high acidity with a value of 7 being neutral) of precipitation in Massachusetts is near

4.2, approximately six times more acidic than uncontaminated precipitation. Acid levels vary seasonally and can be two to five times more acidic in summer than in winter. Higher concentrations of sulfur dioxide and nitrogen dioxide have been associated with winds from the southwest as have reduced visibility and higher concentrations of particulates. Data continue to confirm that long-range transport of pollutants from south and west of Massachusetts is a major source of acidic pollutants in Massachusetts and New England. It is estimated that Massachusetts contributes between 10 and 30 percent of the acidic deposition which occurs within the state. New England is estimated to account for only three percent of emissions generated in the United States. However, as a major importer of electrical power from outside the region, Massachusetts contributes indirectly to acid emissions from other regions.

Although the impacts of acid deposition in Massachusetts were not observed until the late 1970s, there is evidence that man-made acid pollutants have been contributing to the cumulative loss of acid neutralizing capacity in the Commonwealth over the past several decades. Emissions of nitrogen oxides are estimated to have increased steadily since the early 1900s, with more rapid increases since about 1950. Automobiles and trucks are considered the principal sources of nitrogen dioxides. Sulfur dioxide has been emitted into the atmosphere in significant amounts in the Northeastern United States since the early 1900s. These emissions have varied only slightly from current amounts since the 1920s.

Not enough data exist to demonstrate changes in acidity and acid-neutralizing capacity prior to the early 1970s. It is

speculated, however, that given known levels of emissions since the beginning of the 20th century, the environment has been absorbing these acids through its natural ability to buffer against such changes. During the late 1960s and early 1970s the buffering capacity of natural systems in some regions of the country and the Commonwealth was exhausted, and phenomena such as "sulfate breakthrough" became possible. Sulfate breakthrough describes that process whereby a watershed is no longer able to buffer against excess atmospheric acids and the alkalinity of the surface water itself begins to show serious and rapid signs of decline.

### Resources Affected

By 1988 it had been shown that fully 64 percent of the Commonwealth's surface waters was vulnerable to acid deposition and 5.5 percent (185 lakes, ponds and streams) was already acidified (alkalinity < 0 ppm and pH < 5.0). With constant or even slightly declining levels of acid deposition, such acidification is likely to continue. The acidification of surface waters is influenced most by the acid-neutralizing capacity of the surrounding watershed as well as the rate of deposition. Those watersheds most at risk are those with soils with limited buffering capacity. In Massachusetts, northern Worcester County and southeastern Massachusetts are the most sensitive and have the highest percentage of acidified, critical and endangered surface waters.

The biological resources of aquatic ecosystems are clearly affected by increased acidity and associated changes in water chemistry. While declines in fish populations are difficult to document because of the lack of historical data, what data do exist suggest that where

acidity has increased corresponding declines in fish survival are likely. Quabbin Reservoir has lost 75 percent of its acid neutralizing capacity in the past forty years. Research has shown that increased acidity and loss of alkalinity have made it difficult for rainbow trout, smelt and other species to survive.

Studies have also shown that acid deposition plays a role in the release of aluminum, mercury and other heavy metals into the environment. Bioaccumulation of toxic metals in aquatic organisms and fish suggests that predators and humans feeding on those fish will accumulate even higher levels of those toxic metals. Higher concentrations of aluminum and other metals have clearly been shown to affect survival of fish, the ability of many fish species to spawn and the survival of young fry. Although the loss of fish is a major concern, impacts on other aquatic plant and animal species are of equal significance to the over-all health of aquatic ecosystems. Fresh water mussels, snails and crayfish, for example, require a supply of calcium and are often early casualties of the process of acidification.

Terrestrial effects have proven to be more complex and less easily related to direct effects of acidity. Yet, related air pollutants have been demonstrated to affect the health of various plant species and acid deposition, in conjunction with other stresses, is implicated in forest and plant health throughout the world. Some 2,500 acres of red spruce and sugar maple in the Mt. Greylock area appear to be experiencing damage due to acid deposition and related air pollutants. Nor can acid deposition and air pollution be eliminated as contributing factors to decline in other areas of the state. Subsequent field studies have shown that,

for sensitive species including red spruce, norway spruce and sugar maple, forest decline is a significant problem in some areas of Massachusetts.

Studies at the University of Massachusetts Suburban Experiment Station in Waltham have shown that plants sensitive to pollutants like ozone produce pollen which is ozone sensitive. Researchers have screened the pollen of many native and horticultural plant species for ozone sensitivity and found that ozone may well impact the reproductive ability of many important plant species. The long term effects of ozone and acid rain on plant pollen may lead to changes in the composition of natural plant communities and differential survival of shade and forest trees. Such changes in forest ecosystems may affect the types and number of wildlife species they can support.

It has also been shown that acid deposition can have both direct and indirect effects on public health. Acidic drinking water can corrode distribution pipes and result in toxic metal levels in excess of drinking water standards. Acidic pollution has been related to hospitalization in Massachusetts for respiratory disease. Sulfur dioxide, nitrogen oxides, carbon monoxides and fine particulate matter are all implicated in increased hospital admissions.

The effects of acid deposition on cultural resources are also well documented. While some of these resources can be protected at significant cost, many are experiencing irreversible damage. In Boston alone, replacement costs for galvanized steel were estimated in 1984 at \$33 million per year and damage to paint was estimated at \$31 million per year.

## Control Measures

The only true relief to the problem of acid deposition in the Northeast is an effective national emissions control program. It is critical that emissions be reduced to a level sufficient to halt the trend toward further acidification of sensitive natural systems. The Commonwealth has taken aggressive steps within its own borders. The Massachusetts Acid Rain Control Act of 1985 (MGL CHP.590) is currently being implemented and will result in a further reduction of approximately 30 percent in in-state emissions. The recent decision to require the use of vapor-catching gasoline pump nozzles will substantially reduce volatile organic compounds, which are significant contributors to both ambient ozone pollution and acid deposition.

There are numerous control technologies and strategies available to reduce or eliminate the emissions that lead to acid deposition. These include fuel switching, clean-coal technology, energy conservation, scrubbers and alternative energy production. Energy conservation is clearly the most effective and efficient since all fossil fuel consumption leads to some measure of pollution, however limited. To the extent that we can substitute energy from solar, wind and hydroelectric sources for those that depend on combustion of fossil fuels, acidic pollutants are also reduced considerably.

## GLOBAL CLIMATE CHANGE

Global warming results from the so called "greenhouse effect". Sunlight or solar radiation, which passes through the

atmosphere, is absorbed by the earth's surface and converted to infrared energy or heat. The earth's heat radiates out towards space but, rather than passing through the atmosphere, is trapped by greenhouse gases, thus creating a warming effect.

The most significant greenhouse gases are carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), chlorofluorocarbons (CFCs), and nitrogen oxides (NO<sub>x</sub>). Large amounts of carbon dioxide and equally-damaging but smaller amounts of other global warming gases are released by human activities such as burning of fossil fuels, deforestation, agricultural practices and chemical use.

CO<sub>2</sub> is thought to be the principal contributor, roughly 50 percent, to the greenhouse effect. From 1980-1985, the world's CO<sub>2</sub> emissions were 20.6 billion tons per year. The United States is the single largest contributor. Massachusetts contributes approximately .3 percent of the global CO<sub>2</sub> (70-80 million tons per year as of 1987).

Carbon dioxide emissions come from burning of all fossil fuels whether in power plants, motor vehicles, industrial processes or buildings. The major natural source is forest fires.

In contrast to other greenhouse gases, CFCs and related halogenated compounds are not naturally present in the atmosphere. CFCs have been manufactured during the past 50 years for use as solvents, refrigeration and air conditioning agents, aerosol propellants and sterilants, and as blowing agents for foam packaging, cushioning, and insulation board. Bromine-containing compounds are used predominantly in fire extinguishers and firefighting practices. CFCs and similar compounds are

responsible for approximately 15 percent of the greenhouse effect.

Chlorofluorocarbons evaporate into the atmosphere and cause environmental problems in two ways. Because CFCs are such stable compounds, they do not decompose through the usual photochemical processes and have become an important class of chemicals that store heat in the troposphere. CFCs are also carried into the stratosphere, where there is enough energy to strip out the chlorine and other halogen atoms. These react with and destroy the ozone molecules which absorb and screen out ultraviolet energy resulting in stratospheric ozone depletion.

Methane, which contributes about 20 percent to the greenhouse effect, is generated primarily by anaerobic bacteria during decomposition of organic matter. Major sources of CH<sub>4</sub> include landfills, sewage, wood and agricultural waste decomposition, livestock, gas pipeline leaks, and coal mining.

Nitrogen oxides include nitrous oxide, nitric oxide, nitrogen dioxide and other forms of oxides of nitrogen. Complex reactions take place when nitrogen in any form is released into the atmosphere. Fossil-fuel burning, such as at power plants and industrial facilities, in auto engines, and during biomass and forest burning, produces the bulk of nitrogen oxides. Large amounts of nitrogen oxides are also released from agricultural use of nitrogen-based fertilizers.

### Resources Affected

Changes in climate, ocean level, and support systems for the earth's resources will be unprecedented if the current increase in accumulated global warming

gases is not abated. EPA estimates of possible sea level rise of six to eight feet in the next 100 years would bring devastation to Massachusetts coastal resources and the people who live there. As an example, a one-foot sea level rise would put Long Wharf and parts of Logan Airport under water during a coastal storm.

The earth's atmosphere has been warming very slowly since the height of the last ice age 18,000 years ago. During the past 100 years, as a result of carbon release associated with the industrial revolution begun in the mid 1800s, the atmosphere has been warming more rapidly. CO<sub>2</sub> levels have risen 25 percent over those prior to the industrial revolution and temperatures have also risen during this time, but at a much slower rate. Concentrations of CO<sub>2</sub> have risen 8 percent since 1958 and concentrations of CH<sub>4</sub>, NO<sub>x</sub> and CFCs have also increased.

The National Academy of Science projects a 75 percent probability of CO<sub>2</sub> doubling between now and the year 2100. A doubling of CO<sub>2</sub> could eventually raise the average temperature of the earth's atmosphere between 1.5° and 4.5° C (3°-8° F) due to the intensified effects from climate feedback.

Given the short amount of time during which such temperature increases will occur, it will be impossible for earth's major ecosystems to adjust. The expected unparalleled changes would have dramatic impacts upon natural and man-made resources.

At the present rate of one foot per 100 years of sea level rise, Massachusetts now loses 65 acres of coastal land per year and will lose 3,000 acres by the year

2025. At EPA's projected rate, even using a mid-range number of 5.5°F for temperature increase, by the year 2025 between 7,500 and 10,000 acres of existing Massachusetts coastal land will be lost.

Shoreline recession takes place from both wave-produced erosion and passive loss from sea-level rise. There will be both non-storm flooding of upland and more frequent flooding during storms.

The vegetated coastal wetlands will be unable to adjust fast enough to sea level rise. In cases where coastal uplands have been developed, vegetation will be unable to migrate up the shore slope, and the saltmarsh will rapidly drown. New England could lose two thirds of its saltmarsh by 2100.

Storm and rainfall patterns would be affected by global warming. Because sea surface temperatures are expected to warm, more ferocious hurricanes can be expected. A 6° increase in sea surface temperature would double the force of hurricanes experienced to date. Catastrophic damage to the New England coast, such as occurred during the 1938 hurricane with its 15-foot sea level rise, might occur more frequently.

All coastal areas would be affected by sea level rise. Both public and private residential and commercial buildings and operations will be affected, as will transportation corridors, harbors, ports, and their support facilities.

Rapid climate changes would affect all soils, vegetation, and animal life, some more dramatically than others. Any change in temperature will have an impact on habitat distribution, including shifts in vegetated zones, and on animal migration patterns. Changes in the length

and intensity of growing seasons would cause changes in water requirements for agricultural crops and livestock, therefore requiring modification of farming practices. Other resources, such as forest products, may be lost because some species will be unable to adapt to temperature changes.

As CO<sub>2</sub> levels rise and temperatures change, nutrient cycles change. Although some plants will be able to take advantage of the new climatic conditions and grow very well, others will not. The higher the temperature and the more rapid the climate change, the larger the percent of species lost. The diversity of plants and animals will decrease, carrying ripple effects throughout aquatic and terrestrial ecosystems.

It is not certain whether changes in climate will lead to frequent and more extended wet periods or periods of drought. For example, dramatic climate change could cause a rise in the water table from excessive rainfall and/or depletion in fresh water by evaporation. Each scenario would bring a change in reliability of water quantity and quality. During drought, where supply was reduced due to diversion or evaporation plus excess demand, concentration of pollution, especially in lake and river water supplies, would result in a decline in water quality which could lead to public health problems. The reverse would be true during higher rainfall, i.e., where pollution dilution took place, water quality might be enhanced. Sea level rise would cause salt water intrusion and loss of some fresh water supplies.

Increased ambient temperatures due to global warming would increase energy demands to cool the human environment. Warming would also exacerbate air

pollution problems such as tropospheric ozone, haze, and acid deposition.

Ground-level ozone levels would increase due to warmer temperatures because sunlight is the driving force, along with nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOCs), in ozone formation. The greater the temperature and ultra-violet radiation intensity in an area with VOCs and NO<sub>x</sub>, the greater the severity of ground-level ozone. Warming would cause increases in both NO<sub>x</sub> and VOC emissions. As fossil fuel generated electrical demand increases for air conditioning, power plant NO<sub>x</sub> emissions would increase. Gasoline VOC emissions would increase because gasoline volatility, or evaporative quality, increases with ambient temperatures.

Global climate change could exacerbate acid deposition problems. The increased energy demand for air conditioning brought on by temperature increases would increase SO<sub>2</sub> and NO<sub>x</sub> emissions from fossil fuel power plants, which would trigger increases in acid deposition. The impacts of acid deposition would depend upon what climate changes occur. For example, changes in rainfall amounts and location could either moderate or intensify the effects of acid deposition upon sensitive water bodies, soils, and vegetation, including forests.

### Control Measures

There are two ways to slow or halt global warming. One is to reduce the Earth's production of greenhouse gases, especially CO<sub>2</sub>. The other is to increase the Earth's CO<sub>2</sub> receptor capacity by planting (and not destroying) trees. Programs that increase energy efficiency and discourage unnecessary use of automobiles are steps in the right

direction.

To stop or slow the depletion of the ozone layer, we will need to stop producing and using chemicals, such as CFCs, that destroy ozone molecules. Substitutes for aerosol propellants, the cooling compounds used in air conditioning, and solvents need to be developed.

## **SOLID WASTE**

Every day of the year, each citizen of the Commonwealth generates just over nine pounds of waste. All of this material, trash from our lunches, residue from an industrial process, an old refrigerator and today's newspaper, must be disposed of in an environmentally safe manner. A failure to ensure safe disposal of those materials that we throw away risks serious damage to our water, air, land, and wildlife. Our ability to find a home for our trash, or solid waste, is further complicated by nature of our throw-away society. As we look for greater convenience and ease of use from consumer products, we throw away more and more.

From the 1700s until the mid-1950s, the Commonwealth relied on open burning and/or dumping to dispose of solid waste. Until 1970, open burning was considered by many to be a simple and effective method for reducing the amount of waste buried. However, awareness of the environmental hazards of air pollution increased and, in 1970, Massachusetts recognized the threat related to uncontrolled burning of solid waste and issued air pollution control regulations prohibiting it in most forms. Relatively crude incinerators were constructed to replace open burning, but they were soon found to be polluting as

well. Consequently, Massachusetts communities reverted to reliance on landfills.

Even as the shift back to nearly total dependence on landfills for solid waste disposal was taking place, the engineering profession and environmental community understood the fault of this transition. Poorly constructed landfills risk contamination of both surrounding land and underlying ground water. Regulations issued in 1971 distinguished between sanitary landfills and dumps and forced many sites to close or radically improve their operations. With this wave of concern about landfilling came a willingness to invest in new technologies. Thus, in 1975, Saugus became host to the first resource recovery facility (waste to energy) in the nation.

This year, the Commonwealth will generate approximately 10 million tons of solid waste, more than 6.6 million tons of which is municipal solid waste (MSW), largely paper, leaf and yard wastes, metals, glass, food wastes, and plastics. MSW includes residential and commercial waste streams. The residential waste stream accounts for 51 percent of MSW while the commercial waste stream (generated by institutions and business) accounts for 49 percent. The remaining 3.4 million tons of solid waste include: industrial wastes, sludge, demolition and construction debris, used appliances or white goods, tires, waste oil, asbestos, and other solid wastes that require special handling in collection and processing or disposal at special facilities.

## **Resources Affected**

Solid waste disposal has a broad effect on the environment. Dumping onto the land creates landfill leachate which

threatens our ground and drinking water. Created by rain water that percolated through the trash, leachate picks up many of the organic chemicals, heavy metals and other contaminants in the trash. These contaminants then move to the ground and surface water systems and eventually end up in our drinking water supply. In addition, the decomposition of organic materials in a landfill creates methane gas. This odorous vapor is both toxic and highly flammable.

Incineration of solid waste is the most widely available alternative to landfilling. Because burning trash reduces it in volume by 75 percent (the remainder is ash) and creates valuable energy, it is preferred to landfilling. However, incineration also poses environmental risks. The first of these is air pollution. Incinerators emit a variety of pollutants including heavy metals, acid gases and organic compounds such as dioxins and furans. While sophisticated control equipment required by Massachusetts law and regulation diminishes the threat of these materials, some pollutants are still emitted into the air. The second environmental concern is the ash produced by combustion. Coming from both burner residue (bottom ash) and air pollution control equipment (fly ash), this material contains all of the heavy metals not fully burned. The ash from an incinerator must be landfilled and the metals, because they are elements, do not degrade and therefore pose a threat to ground water. While there is potential to re-use some of these metals, they have not yet been fully proven.

## Control Measures

Massachusetts leads the nation in a shift to processing rather than landfilling solid waste. Over the past 15 years

approximately 150 unlined municipal landfills have closed, replaced for the most part by well designed and operated regional landfills and solid waste combustion facilities.

Today Massachusetts landfills 63 percent of its solid waste. Nationally the figure is 80%. There are 28 regional facilities in Massachusetts. Collectively, they have the capacity to handle 50 percent of the state's municipal solid waste. Twenty-one of these facilities are privately owned.

One of the primary benefits of the reliance on regional facilities in Massachusetts has been the associated closure of the smaller, unlined landfills which can threaten groundwater. Of the 194 active landfills in Massachusetts, only 28 are constructed with liners. The remaining 166 are older, unprotected facilities nearing capacity. One hundred fifty-one of these older sites are expected to close by 1992.

As a result of improved environmental standards and the difficulty of siting new facilities, costs of solid waste disposal have risen rapidly. In response to this need, the Commonwealth in 1985 embarked upon an ambitious program to develop an integrated solid waste management (ISWM) system.

Integrated solid waste management benefits both the environment and the economy. Waste reduction, recycling, and processing limit the variety and volume of materials requiring combustion and disposal. Thus, the entire cycle of resource use, from extraction of raw materials and energy to materials processing, manufacturing, and transportation, is altered to lessen adverse environmental impact. In addition, the

disposal of fewer, less toxic wastes reduces the potential for surface and groundwater contamination and diminishes the rate at which land is used for the disposal of trash.

An integrated management scheme is cost effective. When life-cycle costs of solid waste processing and disposal facilities are calculated, it becomes evident that an integrated system is preferable. Recycling (at \$0-\$35 per ton) and leaf and yard waste composting (at \$10-\$20 per ton), even with today's unstable market for their products, are less costly per ton of MSW than combustion (\$25-\$70 per ton) or landfilling (\$25-\$65 per ton). Applied to solid waste management decision-making, the ISWM hierarchy ensures that waste materials are diverted to the most appropriate management method based on that material's physical and chemical characteristics. Finally, diversification of waste handling is a promising strategy. Should one component be found faulty, its repair or replacement will have minimal impact on the management capacity of the whole system.

In support of developing an integrated solid waste management system, the state will apply this ISWM hierarchy in analyzing site assignment and facility permit proposals. Local and regional decisions concerning solid waste in Massachusetts should be consistent with efforts which reduce the amount of waste produced (particularly that which is toxic, either in production or disposal); recycle and re-use (including compost) those components of the waste stream that can be recycled and re-used; combust the balance of the waste stream which cannot be reduced, recycled or re-used, but which can be safely combusted; landfill only those wastes which cannot reasonably be

reduced, recycled, re-used or burned.

## HAZARDOUS WASTE

Hazardous wastes are produced in nearly all industrial processes, as a by-product of the service sector, and in our own homes. They are generated by electronics and chemical manufacturing, and result from dry cleaning, photoprocessing operations, and autobody shops. In our households, cleaning agents and pesticides are examples of products that eventually become hazardous wastes. Waste oil, solvents used for cleaning, sludges laden with heavy metals and paints comprise the bulk of hazardous wastes. It is estimated that in 1987 over 250,000 tons of hazardous wastes were generated in Massachusetts. Safe management of these wastes is the responsibility of all who generate them.

In the mid-1970s, people became very concerned when they discovered enormous toxic burial sites, warehouses filled with leaking drums, and abandoned wastes found on roadsides and remote areas, and learned about explosions from mixing incompatible wastes. Toxic wastes seeped into ground and surface water, spoiled land, and released airborne toxics. In some cases, these wastes caused detrimental health effects and destroyed natural systems.

To address uncontrolled waste storage and disposal, the U.S. Congress passed the Resource Conservation and Recovery Act in 1976 to establish a national program for the management of hazardous wastes. The Massachusetts Hazardous Waste Management Act was enacted in 1979. Shortly thereafter, Massachusetts adopted regulations which established a comprehensive program for controlling

waste at every point where the waste is handled. A system of tracking waste from "cradle" to "grave" was instituted to prevent illegal disposal.

In 1984, the Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act were enacted. These amendments placed even more stringent controls on management of wastes in landfills, banned the land disposal of wastes unless they were treated using the best technologies available, and required an extensive cleanup program for all hazardous waste disposed at companies managing hazardous wastes.

1987 data show us that there are over 13,000 registered generators of hazardous waste in Massachusetts. While half of the waste is produced by small and very small quantity generators, they comprise more than 89 percent of the number of generators. There are 1,573 large quantity generators that produce more than 1,000 kilograms per month; 9,154 small quantity generators that produce more than 100 kilograms per month; and 3,109 very small quantity generators that produce 0-100 kilograms per month. The fastest growing group of generators is the very small quantity generator. The Department of Environmental Protection receives over 100 registrations per week from this group.

In Massachusetts, there are 27 facilities storing, recycling and treating hazardous wastes. Of these, 10 conduct only storage of hazardous waste at the site of generation while 17 facilities offer commercial services for storage, recycling or treatment of hazardous wastes. All disposal of hazardous waste is done at out-of-state facilities.

Facilities conducting beneficial re-use and recycling of waste are licensed in Massachusetts. Over 800 licenses have been issued for recycling of solvent still waste, waste oil reclamation and burning of waste oil for energy recovery.

### **Resources Affected**

When hazardous wastes are not properly managed, releases into the environment cause contamination of groundwater and surface water, result in noxious and harmful emissions to the air, and irreparably harm the land. Typical toxic compounds found in hazardous wastes include arsenic, benzene, cadmium, carbon tetrachloride, chloroform, chromium, dichlormethane, mercury, PCBs, toluene, vinyl chloride and xylene. Toxic metals and pesticides can accumulate in the tissues of birds and mammals causing birth defects and premature death. Exposure to toxic chemicals in the work environment, drinking water, food and air can affect human health in often undetected ways. Increased fatigue, headaches and dizziness can result from chronic exposure to relatively small quantities of toxic chemicals. Reproductive problems, neuro-behavioral effects, cancer and other life-threatening diseases also arise from more potent forms of hazardous wastes.

### **Control Measures**

Safe and relatively simple waste management techniques are the means to prevent releases to the environment during the handling, storage, treatment, recycling, transportation and disposal of hazardous wastes. The regulations mandated by the Massachusetts Hazardous Waste Management Act are far reaching. They define which wastes are hazardous, set up a program for large and small

generators of hazardous waste to obtain identification numbers for accountability, detail management requirements for proper storage, labelling and handling of wastes, establish financial and insurance requirements, license companies that store, transport and treat waste, and institute a system of tracking wastes from the point where they are generated until they are safely disposed or recycled.

Over 800 enforcement actions per year bring violators into compliance. Inspectors conduct more than 500 inspections each year at companies generating and managing hazardous wastes. These inspections ensure compliance with the regulations and help educate people about what they can do to achieve and remain in compliance. Extensive industry, community and citizen outreach programs also educate people about their responsibilities to properly manage hazardous wastes.

The recently enacted Toxic Use Reduction Act sets a goal of 50 percent reduction of hazardous waste generated by 1997. Source reduction programs strongly emphasize substitution of materials to avoid production of hazardous waste, substitution of less toxic materials and re-use and recycling of wastes.

## **HAZARDOUS WASTE SITES**

Releases of hazardous wastes include both spills of oil and hazardous materials (either in transportation or by users) which are limited in scope and can be cleaned up quickly, and disposal sites, which, due to the greater amount, extent, or degree of hazard, require further assessment of the problem before an appropriate course of action can be undertaken. In general, a spill is

characterized by the emergency nature of the threat to public health, safety, and the environment, and the rapidity of response required. A disposal site may also require an emergency response, but always requires a more comprehensive approach to protecting public health, safety, and the environment over the long term.

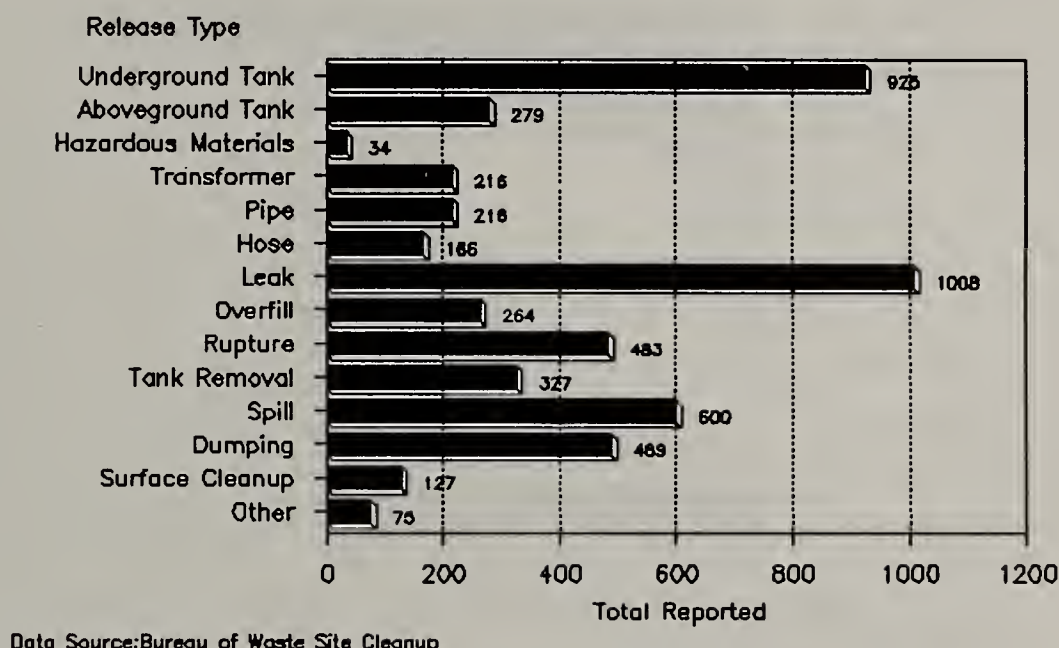
Approximately 5,500 spills of oil and hazardous materials are reported to DEP annually. The releases which create disposal sites result from a wide variety of activities with many different contaminants.

## **Resources Affected**

The Department of Environmental Protection maintains data that describe the types of land uses at hazardous waste disposal sites. The sites at which these releases have been found range in size from several hundred acres or entire estuaries to relatively small gasoline leaks at neighborhood service stations. At some sites, only a single contaminant has been released, while at other sites many pollutants have been identified. At some sites the contaminated area is limited to soil close to a leaking tank, allowing for removal of the pollution with relative ease. At other sites, the areas contaminated by releases of oil or hazardous materials have been widespread, with pollutants migrating through soil or groundwater to adjacent property and in some cases to adjoining communities.

Responses appropriate to each release vary considerably as well. Some releases warrant immediate response because they pose an imminent threat to public or private water supplies or because of the their potential for direct contact with oil or hazardous materials, for fire, or for

# TYPES OF OIL/HAZARDOUS MATERIALS RELEASES REPORTED TO DEP FROM 1/88 - 6/89



explosion. Other releases do not warrant immediate action, but require further assessment to determine what remedial response is needed.

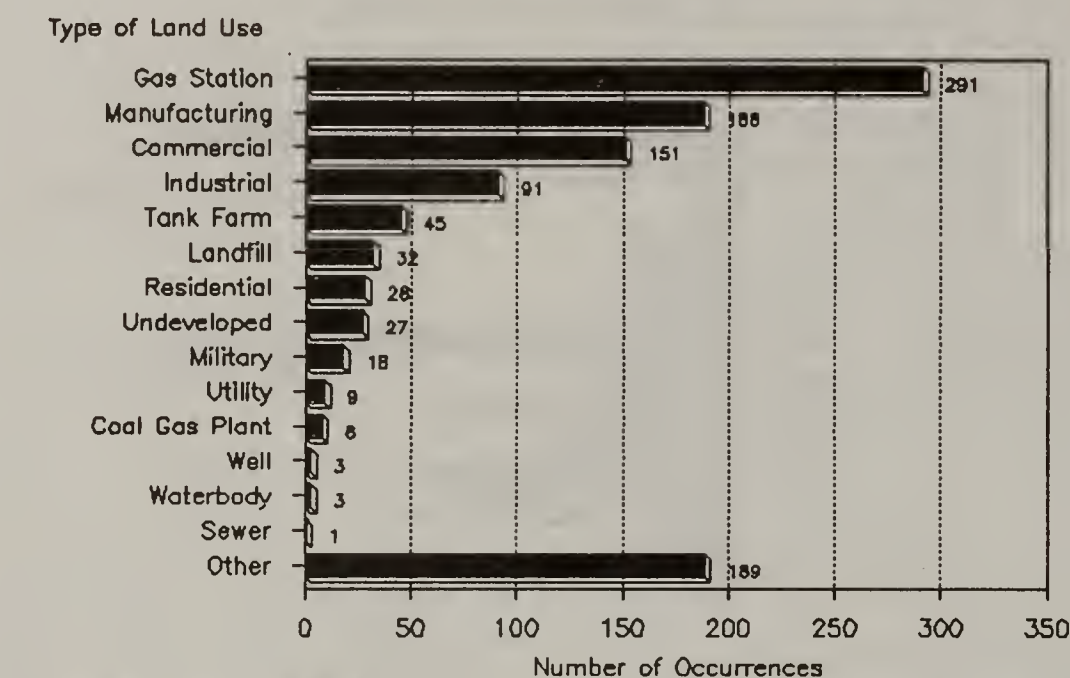
By October 1989, 3,377 sites and locations had received some type of DEP action. At 271 sites, a remedial action has been completed, and no further actions are planned. At another 1,278 sites, releases of oil and hazardous materials have been confirmed and further action is required. Ninety locations have been investigated and found not to be hazardous waste sites, or not to require further action. Another 1,728 locations have been identified which require investigation to determine whether these are disposal sites.

Of the 1,278 sites on the "confirmed" list, 316 have been classified as "priority disposal sites". Another 488 sites have been classified as non-priority sites. The

316 priority sites affect or threaten to affect the following environmental media, projected on the basis of a sample of 100 site classification forms. Criterion may be met singly or in combination with others. Groundwater contamination is affecting or threatening public or private water supplies at 170 priority sites. Uncontained migration of contaminants has been found at 85 priority sites. Direct human contact with contaminated material is possible at 42 priority sites. Other criteria were met at 19 priority sites. These criteria include surface water contamination affecting water supplies or aquatic life, threat of fire/explosion, air emissions, exposure to the human food chain, or other special circumstances.

Four hundred and seventy-four confirmed sites have not been classified, and it is not known whether they currently threaten health, safety, public welfare, or the environment. Of the 1,278

## DISPOSAL SITES BY TYPE OF LAND USE



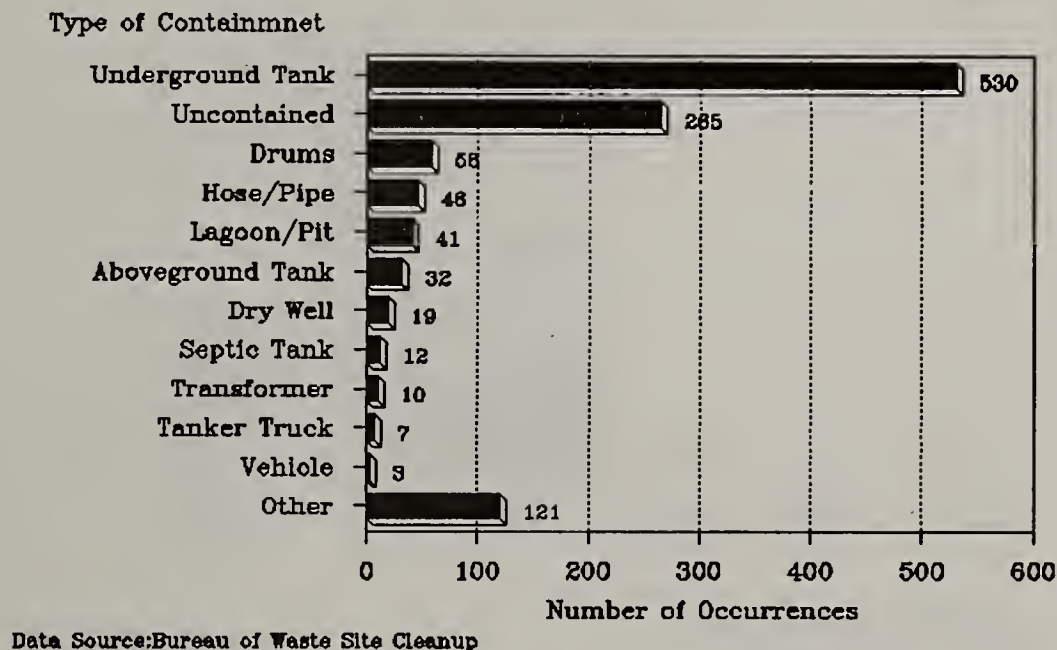
sites on the "confirmed" list, 807 are not currently assigned to staff. Eighty-six of the unassigned sites are classified as priority sites. Of the 1,728 locations to be investigated (LTBIs), 151 are currently assigned to staff. The remaining 1,577 locations are not currently being investigated, and it is not known whether they directly threaten health, safety, public welfare, or the environment. Past experience has shown that a high percentage of locations to be investigated become confirmed sites once they are investigated. If past trends continue, approximately 40 percent of locations that become confirmed sites will be classified as priority sites (those that directly threaten health, safety, public welfare, or the environment). Of the unassigned sites and locations, it is believed that 123 threaten public and private water supplies in the Commonwealth. In the Northeast Region of Massachusetts alone, 39 water supplies have been contaminated, of which

only 3 are being investigated to identify and control sources of contamination.

### Control Measures

Over 20 years ago, the Commonwealth of Massachusetts first started to respond to hazardous waste cleanup problems on a limited basis by cleaning up oil spills that threatened the Commonwealth's surface waters. Additional concerns about illegal hazardous waste disposal resulted in rudimentary regulations governing companies that transported, treated, stored, or disposed of hazardous waste. However, by the mid-1970s, when hazardous waste sites started to emerge as a significant environmental issue, there was no program under which government could readily respond. In 1978, the Massachusetts legislature appropriated \$5 million but it soon became clear that those funds could pay for only a handful of remedial actions, and that the

# DISPOSAL SITES BY TYPE OF CONTAINMENT AS OF 7/15/89

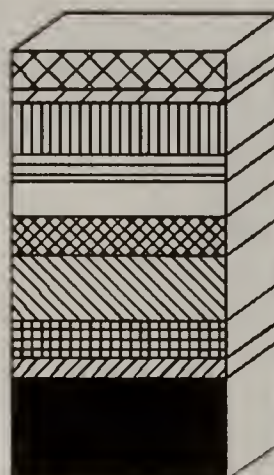


Commonwealth did not have the authority or resources to respond aggressively to the growing threat of hazardous waste sites.

In March 1983, the legislature enacted the "Massachusetts Superfund Law", M.G.L. Chapter 21E, which provided new tools in terms of both expanded authority and greater resources. Chapter 21E was substantially amended in 1986 by a referendum question supported by 74 percent of voters. While the amendments did not change the basic concept of c. 21E, which requires those legally liable to clean up releases of oil and hazardous materials, they did establish deadlines and standards for cleaning up sites. The amendments required "permanent solutions" for cleanup of disposal sites and based the definition of a permanent solution on the risk that the site would pose to health, safety, public welfare, or the environment for any foreseeable period of time.

The 1986 amendments also established timetables for cleanup, requiring DEP to publish and update quarterly lists of confirmed disposal sites and locations to be investigated, and to list 1000 new locations to be investigated annually. Once a property is listed as a location to be investigated, several deadlines must be met. Within one year of listing, a preliminary assessment must be completed that determines the need for further investigation. Within two years of listing, a site investigation must be completed for any location warranting further investigation, and sites must be classified as "priority disposal sites" or "disposal sites". Within four years of the listing, "priority disposal sites" must be fully evaluated, and a permanent remedy must be completed if feasible. If a permanent remedy is not feasible, an initial remedial response action must be completed, and a plan for implementing permanent

# DISPOSAL SITES BY TYPE OF CHEMICAL RELEASED AS OF 7/15/89



Other \* 132  
PCBs 49  
Virgin Oil 178  
Heavy Metals 94  
Chlorinated Solvents 121  
Organics 132  
VOCs 225  
Petroleum 133  
Waste Oil 67  
Gasoline 354

Data Source: Bureau of Waste Site Cleanup  
\*Includes Coal Tar (80), Sludge (17),  
Waste Water (15), and Pesticides (14)

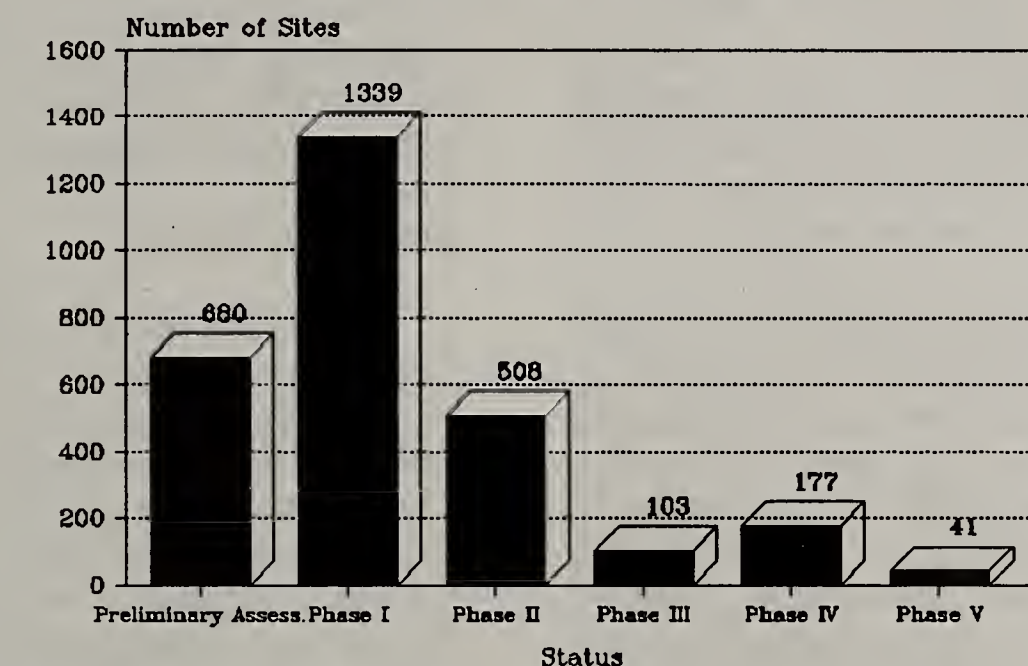
remedial measures must be developed. Permanent remedies must be implemented as soon as feasible technology is available. Within seven years of the listing, non-priority disposal sites must be fully evaluated, and a plan for permanent remedial action must be developed.

In October 1988, regulations called the Massachusetts Contingency Plan (MCP) took effect. The MCP is a set of regulations establishing procedures for identifying, evaluating, and cleaning up releases of oil or hazardous materials to the environment. These regulations provide a list of oils and hazardous materials and a description of the characteristics of hazardous materials that are subject to the MCP spill notification regulations as well as procedures and requirements for notifying the Department of a spill or threat of an oil or hazardous material release. They also provide procedures and requirements to evaluate

and address the nature and extent of a release at a disposal site and characterize and evaluate the risk of harm to people and the environment. Procedures and requirements for involving financially responsible (known as Potentially Responsible Parties or PRPs) and other parties as well as the public are also set out in the MCP.

The process for cleaning up disposal sites is divided into several phases. Sites are discovered, releases are confirmed, the nature and extent of the problem is identified and evaluated, and the risks posed for public and the environment are characterized, remedial strategies are identified, assessed and selected, and remedial measures are designed and built. Most sites are cleaned up by the PRPs. When those legally responsible for releases cannot or will not respond in a timely way, it falls to DEP to respond appropriately. In all cases, it is DEP's

## STATUS OF DISPOSAL SITES AND LTBI<sub>s</sub> AS OF 7/15/89



Data Source: Bureau of Waste Site Cleanup

responsibility to ensure that sites are left in a condition so as not to pose risks to health, safety, public welfare, or the environment.

## AGRICULTURAL CHEMICALS

Agricultural chemicals, fertilizers and pesticides are among the most important reasons for the abundant, low-cost food supply in the United States. Yet the use of agricultural chemicals is not without risk. While pesticides are designed to kill or mitigate specific pests, there is potential and actual risk to non-target organisms, humans and the environment. Misuse can result in exposure to the non-target environment and research has shown that in some instances unreasonable adverse effects result from the proper use of registered agricultural chemicals as well. The over-use of fertilizers and resulting run-off have

resulted in unreasonably high levels of nitrates in groundwater and excess-nutrient pollution of surface waters.

Before World War II, agricultural chemicals consisted of naturally derived products. Emphasis for controlling pests and fertilization was based upon more organic programs. Natural manures and compost were the sources of fertilization. Pests were controlled through biological controls, mechanical means, cultural practices and naturally derived pesticides. Yet even these naturally derived products were not without their risks. The use of arsenicals, for example, posed a significant risk of exposure to the non-target environment because they did not breakdown and were passed through the food chain.

At the end of World War II, the agricultural chemical industry began to provide new synthetically derived products

for the control of pests and for fertilization. DDT was one of the first pesticides to be widely used. DDT was credited with preventing a serious outbreak of typhus after WWII. Programs were undertaken to eradicate some of the most serious pests to control diseases such as malaria. DDT and other first-generation pesticides were widely distributed in the environment.

The introduction of these early products to control pests were quickly accepted by government, academia and agriculture as the best means to agricultural productivity. Pests that were previously controlled through programs utilizing biological, mechanical, cultural and naturally occurring pesticides were replaced by synthetic chemicals. The labor, cost and effectiveness of using agricultural chemicals ushered in their widespread acceptance.

It was not until the publication of "Silent Spring" in 1962 that the potential risks of agricultural chemicals were first widely recognized. The disastrous effects of DDT nearly caused the extinction of the osprey and bald eagle. Other first-generation agricultural chemicals began to exhibit such negative aspects as persistence in the environment, risk to non-target species, and the inability to control resistant pests. First-generation pesticides have now been removed from use and replaced with second- and third-generation pesticides which are characterized by their selectivity and ability to break down rapidly.

Evidence has now begun to mount on the risk from the use of these second- and third-generation pesticides as well. As additional data on pesticides currently in use are generated on their fate in the environment and hazard to humans and

wildlife, unsuspected problems are being identified. Recent discoveries include adverse effects on birds when diazinon granules are applied to turf; to marine life from boats treated with tributyltin containing antifouling paints; and to groundwater from a wide-range of agricultural chemicals.

### Resources Affected

Agricultural pesticide impacts to groundwater were first identified in the early 1980s in Massachusetts. The initial evidence focused on pesticide use in the Connecticut River Valley. Two pesticides, EDB and aldicarb, contaminated over 50 private water supply wells and resulted in the closing of West Springfield's municipal water supply. Further groundwater monitoring efforts for other priority pesticides (alachlor, oxamyl, carbofuran, 1,2-D, 1,3-D, dinoseb) did not yield significant findings of adverse impacts. However, detailed assessment studies are on-going through implementation of the Pesticide Ground Water Protection Strategy.

In rare cases, the use and misuse of pesticides can result in acute illness and death. In Massachusetts the improper release of water from cranberry bogs resulted in several fish kills in the mid-1980s. A greater fear in the public's eye concerns the risk of chronic toxicity (i.e., cancer) from exposure to pesticides. Exposure to agricultural chemicals through consumption of food can pose a risk to infants, children and susceptible adults. There is growing pressure from consumers to reduce or eliminate chemical residues in food.

The over-use of synthetically derived fertilizers has resulted in nitrate loading of groundwater, streams and estuaries

through run-off. Since nitrates pose a significant public health concern, affected groundwater may be deemed unsuitable for human consumption. Nitrate loading can also make the groundwater unsuitable for irrigation. Eutrophication of streams and ponds from run-off has resulted in significant degradation of aquatic habitats.

## **Control Measures**

Federal (EPA) and state agencies (DFA) have established regulatory programs to determine the effect of pesticides and manage their use to minimize the potential of unreasonable adverse effects. The Massachusetts program involves pesticide applicator licensing, pesticide product registration, fertilizer registration and pesticide use enforcement.

Over the past decade, efforts have been made to change the philosophical reliance of agriculture upon chemicals. Since the introduction of agricultural chemicals in the 1940s, academia and government agencies have actively promoted the use of agricultural chemicals. But, because of the risks associated with the use of agricultural chemicals and the desires of consumers, a change has been occurring at the federal and state level. The uses of many of these chemicals have been further restricted or eliminated entirely. Massachusetts was the first state to ban the use of chlordane, restrict pesticides that pose a risk to groundwater, and limit aerial applications. Public notification programs have been implemented for lawn care, mosquito control, rights-of-way and certain agriculture applications.

Programs have been developed to change the attitude of farmers toward the

use of agricultural chemicals. By the mid-1980s, investments in Low Input Sustainable Agriculture (LISA) and Integrated Pest Management (IPM) began to show promising results in Massachusetts. LISA and IPM are research initiatives intended to develop methods of growing crops utilizing a least cost/materials approach. Through the IPM Program, the reduction in the use of chemicals while maintaining crop yields has resulted in significant cost savings for the farming community. The success of some IPM programs has resulted in a reduction in pesticide use in some crops as much as 25 to 50 percent. Currently there are IPM Programs in apples, potatoes, sweet corn, strawberries, turf and cole crops. Over the past six years, Massachusetts has invested approximately \$2 million in IPM efforts, with grower and private contributions closely matching this amount.

## **WASTEWATER**

Historically, the many rivers, streams, and especially the coastal waters of the Commonwealth have provided convenient conduits for the disposal of sewage. Over the last 40 years changes in modern technology and lifestyles have resulted in dramatic increases in per capita water consumption with parallel increases in wastewater production. Expanding urban and suburban populations and industrial growth have brought corresponding demands on inadequate infrastructure, particularly in eastern Massachusetts. Planning efforts have not kept up with infrastructure needs, and significant environmental problems have resulted.

The collection and treatment of wastewater are areas where deficiencies have been particularly severe and where cumulative environmental impacts are now

most apparent. The stress on water resources has accumulated steadily, but it was not until the 1950s that these stresses were recognized as threatening to both public health and the environment, and serious attention began to be paid to the problem of wastewater treatment and disposal. Subsequently, the federal government embarked on a massive grants program to aid cities and towns with financial incentives, in addition to regulatory requirements, for constructing the necessary treatment facilities.

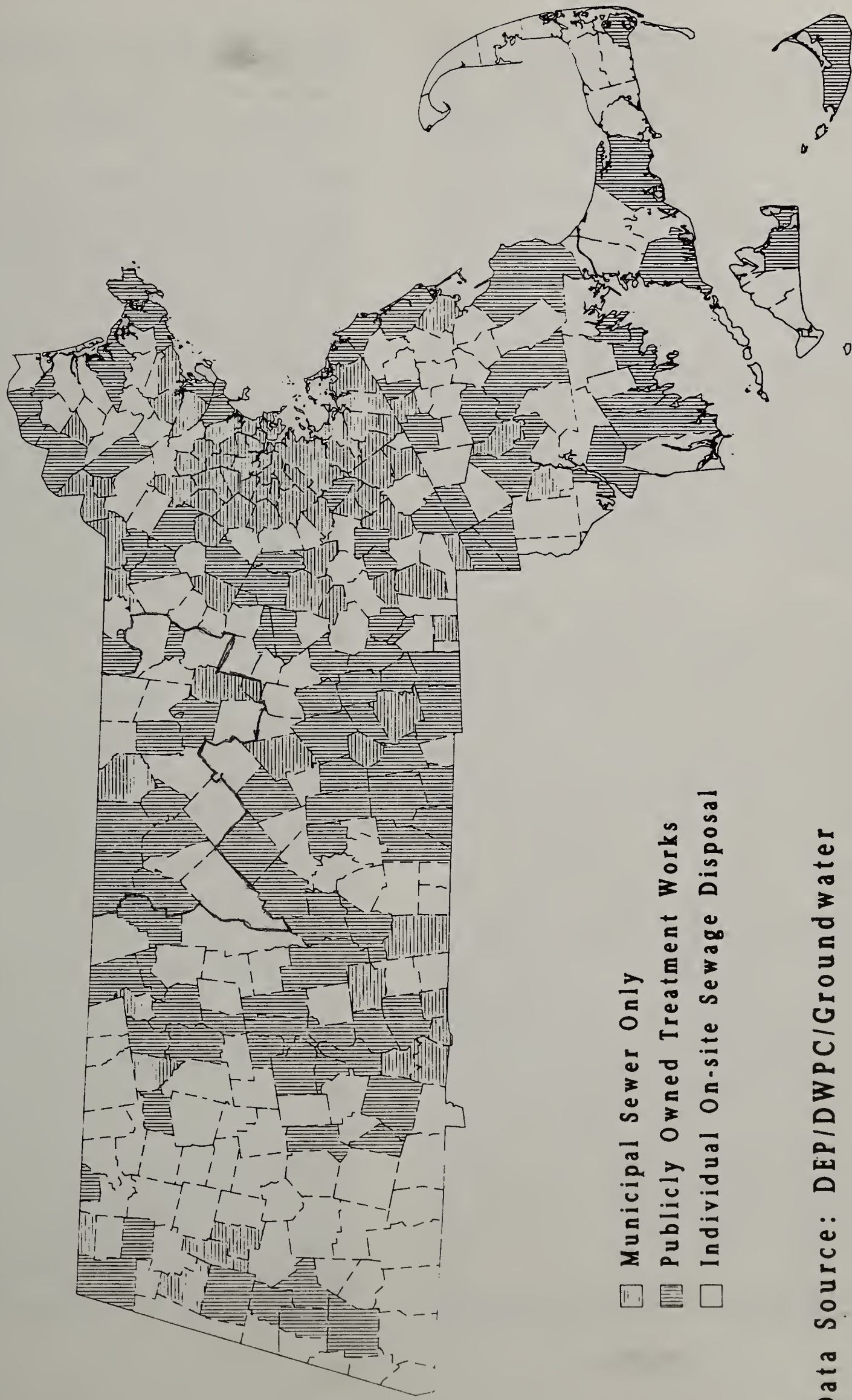
At present, 139 publicly-owned treatment works (POTWs) in Massachusetts have permits under the National Pollutant Discharge Elimination System (NPDES). These POTWs collect and treat over one billion gallons of sanitary and industrial wastewater each day and serve over 70 percent of the state's population. Seventy-five percent of this total daily discharge is to coastal waters, primarily Boston Harbor. An additional 12 million gallons per day of sanitary sewage is treated and discharged to the ground by small privately-owned sewage treatment facilities regulated under the Massachusetts Groundwater Discharge Permit Program (314 CMR 5.00). In addition to municipal and privately-owned treatment facilities, over 650,000 individual subsurface sewage disposal systems (septic systems) operate in the Commonwealth serving approximately 30 percent of the population, mostly in rural areas.

Over the last 30 years many treatment facilities have been built as a result of local, state, and federal efforts. Progress in improving water quality conditions has been a demonstrable result in many water bodies, especially in rivers and streams. However, in spite of state and federal grants programs and regulatory efforts, wastewater treatment goals have yet to be

met in many locations. Surface waters continue to be affected by discharges from the existing facilities, and water quality standards continue to be violated. All of the large coastal dischargers continue to discharge primary-only treated wastes. While facility planning efforts for improved treatment are finally proceeding (largely in response to court-ordered schedules), realization of water quality improvements is a decade or more away in most cases. The Metropolitan Boston Area which is now served by the Massachusetts Water Resources Authority (MWRA) is clearly the largest contributor to the problem in coastal waters. Problems resulting from discharges to groundwater from both privately-owned facilities and from septic systems are of concern because of the potential to contaminate drinking water supplies and adjacent surface waters. Documentation of this problem is difficult and generally the problem is less well known unless a specific resource (a drinking well, for example) has been affected. The cumulative environmental impacts of discharges from multiple sources, including those that are meeting discharge requirements, have rarely been studied.

One result of the expanded treatment efforts and water quality monitoring has been to identify non-point sources of pollution as major contributors to contamination of water resources. Areas such as Cape Cod have had recent increases in closures of shellfish beds which cannot be attributed to point sources. It is expected that there will be further identification of locations which are heavily affected by non-point pollution as full implementation measures for the control of point sources are put in place and contamination that may have been previously masked becomes more identifiable.

# Sewage Treatment in Massachusetts



Data Source: DEP/DWPC/Groundwater

Another major source of contamination is from combined sewer overflows (CSOs), which are found largely in older urban areas where stormwater and sanitary sewers are combined into one system. When the capacity of the system is overloaded, the excess flow overflows into and contaminates the adjacent surface water body. In the case of Boston, the CSOs are perhaps the most important contributor to the pollution of Boston Harbor. In most places in the Commonwealth where they exist, facility planning efforts are under way to correct and maximize the containment of these sources of contaminants. Adjustments in the design of sewage treatment facilities are being made to accommodate the anticipated additional flows that must be treated.

Toxics, pathogens, and nutrients are the contaminants of concern. Toxics can have impacts on public health and on the general health of the aquatic ecosystem. Toxics fall into several categories including heavy metals (such as lead, mercury, and copper), organic substances (such as petroleum hydrocarbons), and chlorinated pesticides. Estimates by the MWRA indicate that POTWs and CSOs contribute 90 percent of the heavy metals and petroleum product loadings to Massachusetts Bay. Total loadings per year to Massachusetts Bay, even with current treatment efforts, are estimated to be 8,000 tons for the common metals and over 26,000 tons for hydrocarbons. Specific impacts are difficult to identify, except that fish and lobster disease are fairly well documented for every urban harbor where they have been looked for. Health advisories have been issued for eating lobster tomalleys from Boston Harbor.

Pathogens are important because of

their effects on public health, primarily through recreational contact with surface waters and consumption of seafood. There have been significant closures of shellfish beds since early this century when sewage contamination of shellfish resources was first recognized as a health threat. In recent years, the Massachusetts Division of Marine Fisheries has documented a near exponential increase in shellfish closures due to both actual and potential pathogen contamination. Federal health authorities insist on the closure of shellfish beds that are in the vicinity of treatment plant discharges as a precautionary measure. To some extent, this requirement has revealed how poorly the siting of outfall locations for treatment plants has been. Although less sensitive to low levels of pathogen contamination, recreational uses such as swimming have also suffered, especially from CSOs near urban areas.

Nutrients are generally less controlled than the other two types of contaminants. Through current treatment technologies but they also affect the health of the ecosystem and, less directly, public health. While treatment plant discharges account for about 45 percent of nitrogen and 80 percent of phosphorous in the total discharges to Massachusetts Bay for example, they are the most controllable of the sources through advanced treatment processes. Nutrients contribute to algal blooms and eutrophication which are evidence of accelerated productivity which can ultimately lead to oxygen depletion, fish kills and other ecosystem damages in both fresh and salt waters. Nutrients may also contribute to the periodic red tides (algal blooms, actually) which do present a public health threat. Recent declines in the productivity of our fisheries are also a cause for concern, and the extent to which excessive nutrients may be

contributing to this problem requires further study.

## Resources Affected

The quality and quantity of our drinking water are of major importance. Once considered an inexhaustible resource in the northeast, recent incidences of contamination of supplies, as well as periodic drought conditions, have forced us to reevaluate previous assumptions. Wastewater disposal is one of several sources of identified contamination.

Recent problems and issues raised in Boston, Salem, and New Bedford harbors attest to the need to address the complex environmental problems that remain in marine ecosystems. Early efforts to control wastewater discharges focused on freshwater resources because they served as primary sources of drinking water and because the marine environment was considered to have an almost infinite capacity for assimilating wastes. To some extent, the misconception about the ability of the ocean to absorb wastes persists today and inhibits our efforts to move towards rapid solutions to the problems. Nationwide research studies in urbanized estuaries have documented and focused the public's attention on the decline in fisheries resources and recreational uses, algal blooms, and anoxic events that can be correlated now with long- and short-term discharges of untreated and inadequately treated wastewater. A \$6.1 billion dollar investment to treat the wastes generated in the Metropolitan Boston area represents the most ambitious water pollution abatement project undertaken in U.S. history. Similar efforts are now moving forward in Salem, Lynn, New Bedford, and Plymouth. It is also increasingly evident that better research and monitoring efforts are needed to

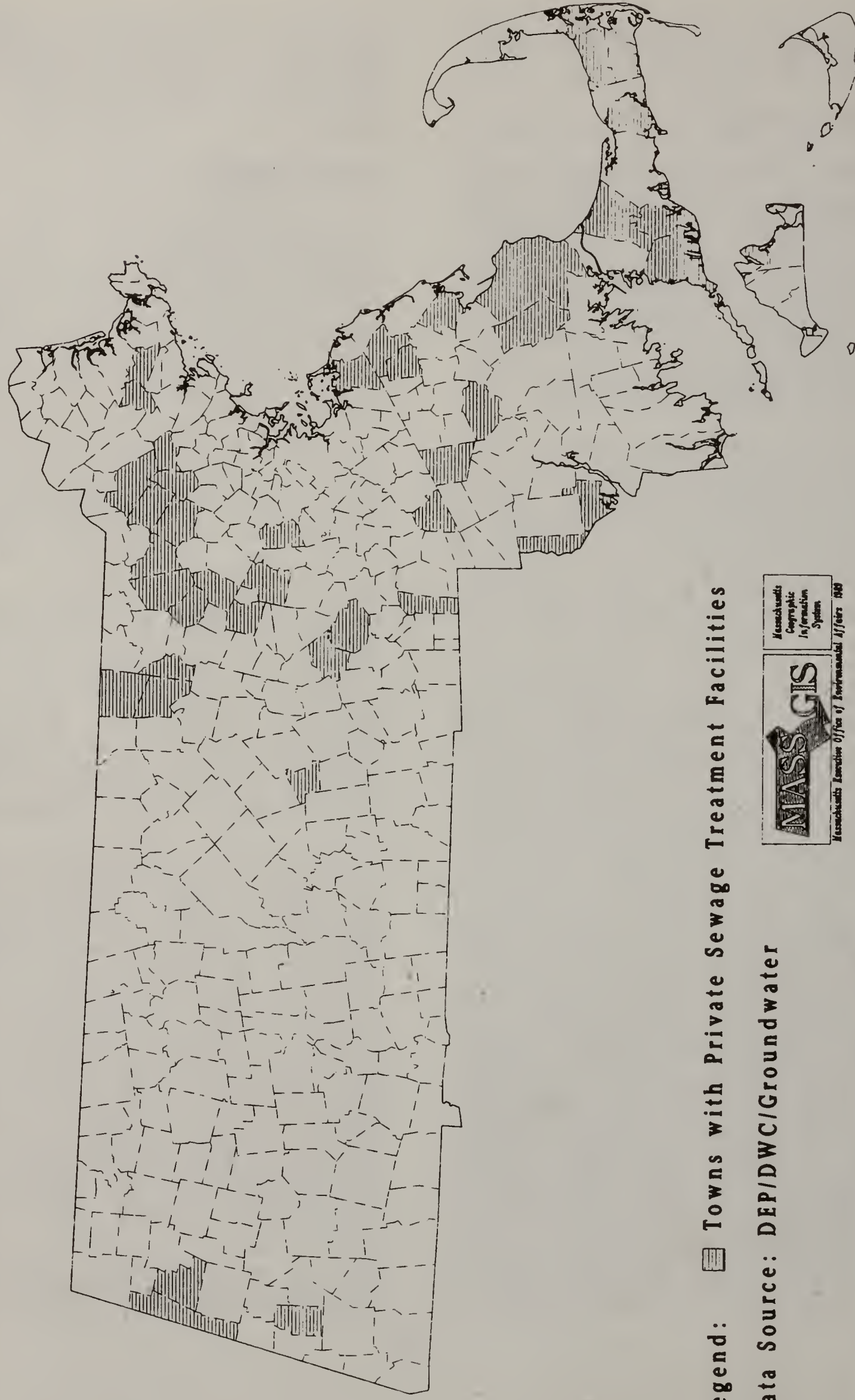
document the effects of on-going discharges, as well as to demonstrate water quality improvements from current controls.

## Control Measures

Current laws require a minimum of secondary treatment for all POTW facilities. Primary treatment is basically a settling process which removes between 30 and 50 percent of suspended particles from the wastewater (and since a portion of pathogens and toxics are associated with particles, they are also removed to some extent by this process). Secondary treatment is a biological digestion process where a mix of microorganisms digests dissolved materials, followed by additional settling where dead bacterial cells and additional solids settle out (and more toxics and pathogens are removed). Advanced treatment generally involves a particular specialized process which aims to correct problems that are not otherwise adequately addressed by primary and secondary processes. Usually, advanced treatment is developed for the removal of nutrients, either nitrogen or phosphorous.

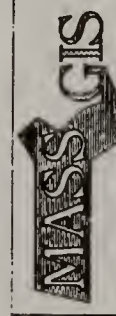
The NPDES permit is the regulatory tool used to limit pollutants in all discharges. Specific allowable maximum levels are set for the common pollutant measurements of concern, including suspended solids, biochemical oxygen demand, chlorine, and oil and grease. In addition, where there are known to be other chemicals of concern in a particular treatment system because of known industrial discharges into the system or because of past problems, specific limits are sometimes also set for individual chemicals such as lead, copper, and other heavy metals and for organic substances such as polychlorinated hydrocarbons (PCBs), pesticides, and various petroleum

# Towns with Private Sewage Treatment Plants in Massachusetts



Legend:  Towns with Private Sewage Treatment Facilities

Data Source: DEP/DWC/Groundwater



Massachusetts  
Geographic  
Information  
System

Massachusetts Executive Office of Environmental Affairs 1993

products. Dischargers are required to monitor their discharges and to submit results to the state and federal regulatory agencies. One limitation of this monitoring system is that the regulatory agencies are not able, because of staffing and fiscal limitations, to adequately verify the results from the monitoring efforts, and the monitoring results themselves are often not carefully scrutinized until the permit is up for renewal (every five years). The result is that violations are often not detected or addressed in a timely manner. Monitoring is most often aimed at end-of-the-pipe water quality and seldom addresses the larger question of environmental and ecosystem health, which is really the level of greatest concern.

## THE PROBLEMS OF GROWTH

Development is the natural and inevitable result of a healthy community. It is an indicator of a strong economy and of future opportunity. Development can be a problem, however, when it is unplanned or unmanaged and adversely affects a community's environmental resources, character or social structure.

The demand to develop the land is driven by many factors, including population growth, the accumulation of wealth, advances in technology and changes in transportation. Some development is unnecessary and inappropriate to an area and the needs of its residents.

The market value of commercial, industrial and residential property at its "highest and best use" is relatively easy to appraise. However, the value of maintaining a pure aquifer beneath a parcel is difficult to determine and is

rarely included in an appraisal. The value of a property's ability to prevent flooding downstream is rarely included, nor is the value of the wildlife habitat the property provides. Many of these non-market values are difficult to assess, not valued by individual property owners, and often unrecognized.

Limited societal control over land use is afforded by zoning. In Massachusetts, power to determine land uses is given to cities and towns. Most have adopted zoning plans which determine which kinds of land uses should go where. Many have adopted open space plans which recommend areas to be protected. Rarely are the two plans effectively related. In fact, typical zoning is often called "fiscal zoning" because its primary outcome is purely economic, without regard for environmental protection.

Add to this two related issues. First, many residents and local officials fail to fully realize the long-term costs of developed land and assume that development will increase revenue without increasing demand for local services. Second, they fail to recognize that the undeveloped status of properties today, such as those managed for agricultural or forestry use, may very well change to developed tomorrow. It is important to realize that our economic system makes it very likely that land will be developed to its maximum economic capacity unless specific action is taken to preserve it and to realize the many benefits for which the market fails to account.

## Resources Affected

Development affects many environmental resources, including

wetlands, waterbodies, air quality, agriculture, and forest resources. The extent of the degradation or destruction of these resources is documented in chapters II and IV of this report. But it is important to recognize that when a parcel of land is developed, not only is the natural resource removed, but it is replaced with something which creates an additional need for that lost resource. When trees are cut down to make way for a highway or a shopping center or a subdivision, not only is the forest's natural filtering system removed, but additional pollution is created. If low-lying riverine property is developed, not only has the absorptive quality of the area, which once soaked up excess rainfall, been destroyed, but there is now additional property that must be protected from flooding by the construction of artificial structures.

All of this has economic consequences and magnifies the demands on the state's infrastructure. In each example above, a no-cost system has been replaced with a land use requiring additional, long-term expenditures, although as stated earlier, these added costs are seldom calculated or recognized.

Uncontrolled development has further economic consequences, as it frequently damages or destroys the scenic values and environmental amenities that are essential in attracting industry and tourism to the state.

## Control Measures

The negative effects of development are mitigated through several existing approaches which include planning, regulation, land acquisition and conservation and tax incentives. Whether the measures currently available to Massachusetts communities are sufficient,

is a topic of debate at all levels of government.

Planning is clearly the most important approach to managing growth. Planners employ several regulatory tools such as zoning and subdivision regulation to direct development in certain areas and manage the growth of their communities. Planners, however, are often faced with less than adequate information and resources to do an effective job and they are frequently confronted with problems created outside of their own borders. It is also increasingly apparent that planning solutions that proved effective in dealing with growth 25 or 50 years ago are not sufficient to deal with the development pressures being experienced today. Recent advances in planning methods and technology, such as the use of geographic information systems, clustered development models and landscape assessment hold great promise if the opportunities for their implementation are afforded.

Tax incentives have been employed with some success in Massachusetts. M.G.L. c. 61 provides property owners with tax benefits if they maintain property for agricultural, forestry or recreational uses. The Massachusetts Wetlands Restriction Program provides similar tax benefits but it has not yet been widely implemented. There are other economic incentive programs, such as transfer of development rights, that could prove effective for the protection of water supplies and other critical resources.

Additional regulation of land uses is afforded through state statutes such as the Wetlands Protection Act and the Massachusetts Environmental Policy Act. Again, these regulatory tools are only as effective as their implementation and

consideration needs to be given to whether or not these tools are adequate to today's challenges.

The placement of land under conservation restrictions and the actual acquisition of important resources are often measures applied with considerable success. This type of effort could be considerably enhanced through creation of funding in proportion to the development pressure being experienced by a community. The Land Bank legislation which has been proposed to the Massachusetts legislature is an example of such a measure.

*Publications and documents used as the basis for information presented in this chapter include the following:*

*"Interim Report on the Findings of the Massachusetts Acid Rain Research Program", R. Taupier, N. Drake and A. Ruby, Mass. Executive Office of Environmental Affairs, 1988. "The Challenge of Global Warming", D. Abrahamson, Natural Resources Defense Council, 1989. "Greenhouse Effect, Sea Level Rise and Coastal Wetlands", U.S. Environmental Protection Agency, 1988. "The Potential Effects of Global Climate Change on the United States", 1988. "Toward a System Of Integrated Solid Waste Management", Mass. Dept. of Environmental Quality Engineering, 1989.*

## CHAPTER IV

### MEASURES OF ENVIRONMENTAL QUALITY

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#### AIR QUALITY

The air over Massachusetts is dominated by several naturally occurring gases: nitrogen, oxygen, argon, and water vapor. In addition to these gases, there are trace amounts of natural inert gases, and minute concentrations of naturally occurring benign and toxic gases. Within the gases are particles of various sizes and shapes emitted from natural sources such as the ocean or soil. Added to the natural atmosphere are the wastes emitted by human activities, the gases and particles that cause air pollution.

Our air fuels the basic life processes of humans, animals and plants. A dynamic balance exists between the atmosphere and the biological, chemical and physical components of terrestrial and aquatic ecosystems.

The atmosphere shelters living organisms from harmful solar radiation and moderates cold and warm climatic cycles by trapping heat and exchanging air. These processes occur on a global scale and the Commonwealth's air resources cannot be separated from them.

#### Pollutants and Sources of Stress

Massachusetts, in conjunction with the federal Clean Air Act, has specified permissible ambient concentrations for six of the best studied air pollutants. These maximum concentrations, known in the Clean Air Act as National Ambient Air Quality Standards (NAAQS), are believed to be protective of the public health and

welfare with an adequate margin of safety.

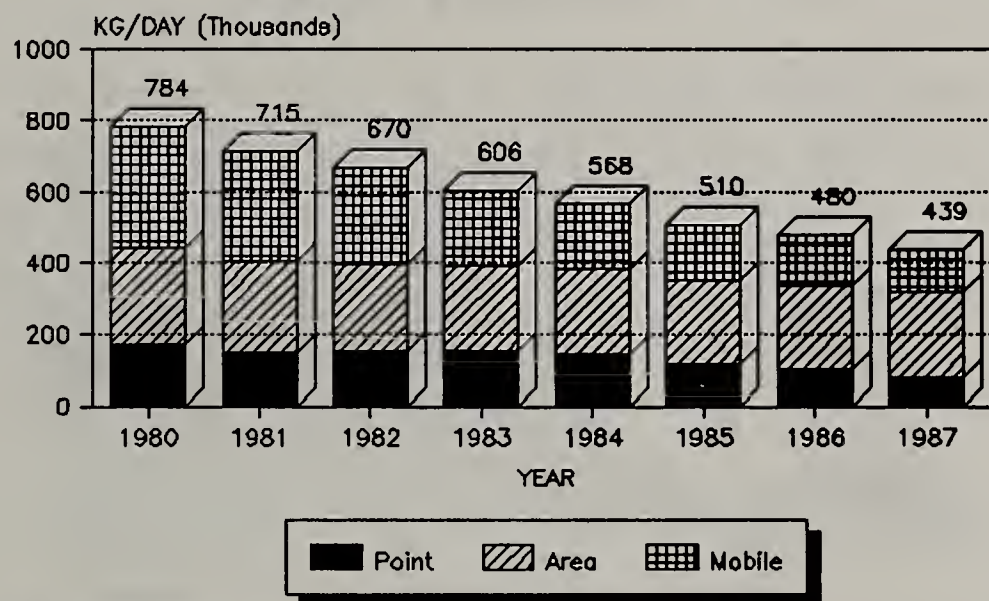
These six pollutants are known as criteria pollutants because state and federal research efforts have established health and welfare impact criteria for them. They are the gases sulfur dioxide and carbon monoxide, which can be measured directly; particulates and the subset of lead particles, which are collected on a filter and weighed; nitrogen oxide; and ozone, a pollutant that is caused when emissions of VOCs, NO<sub>x</sub> and CO combine in the presence of heat, sunlight and humidity.

In addition to these six pollutants, there is a host of other toxic air contaminants for which specific ambient limits have not been agreed upon by the scientific or regulatory community. They include metals, VOCs such as benzene, and chlorinated solvents (hydrocarbons). The Department of Environmental Protection has researched allowable ambient concentration levels 100 additional contaminants. Massachusetts regulates emissions of these chemicals by prohibiting the emission of any air contaminant in such a way or in such quantity as to cause or contribute to a condition of air pollution.

#### Measures of Quality

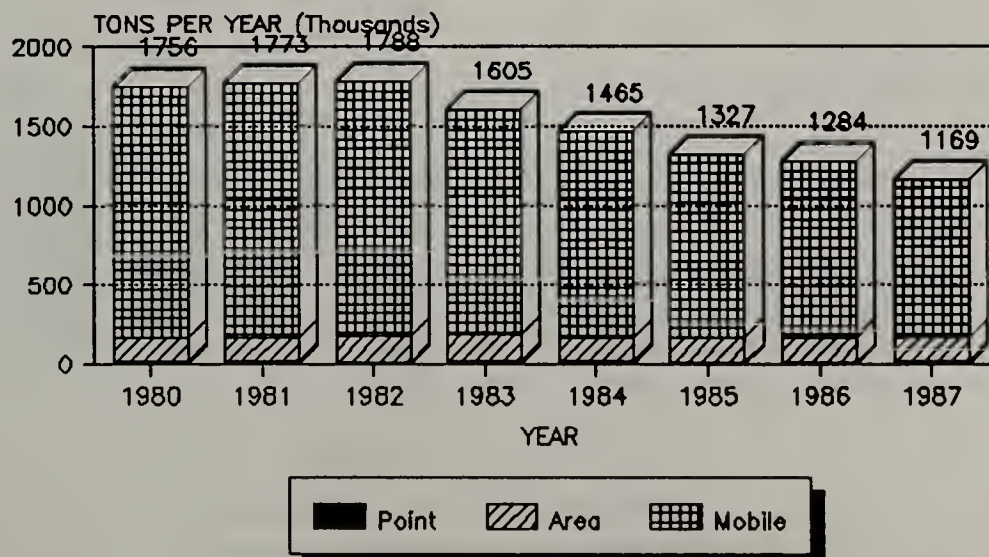
The Division of Air Quality Control within DEP routinely monitors air quality for the most pervasive contaminants (including criteria pollutants) at 40 sites around the Commonwealth. Monitoring helps to define air pollution problems and identify how much more

## 1980 TO 1987 STATEWIDE VOC EMISSIONS FROM POINT, AREA AND MOBILE SOURCES



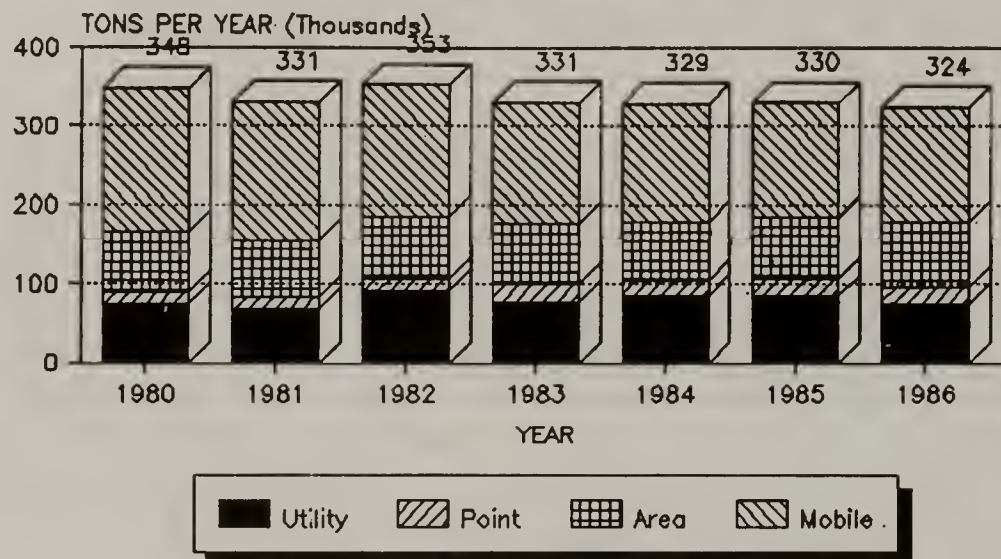
Data Source: DEP Division of Air Quality  
 "Massachusetts Demonstration of Reason-  
 able Further Progress - Ozone"; 1988

## 1980 TO 1987 STATEWIDE CARBON MONOXIDE EMISSIONS FROM, POINT, AREA & MOBILE SOURCES



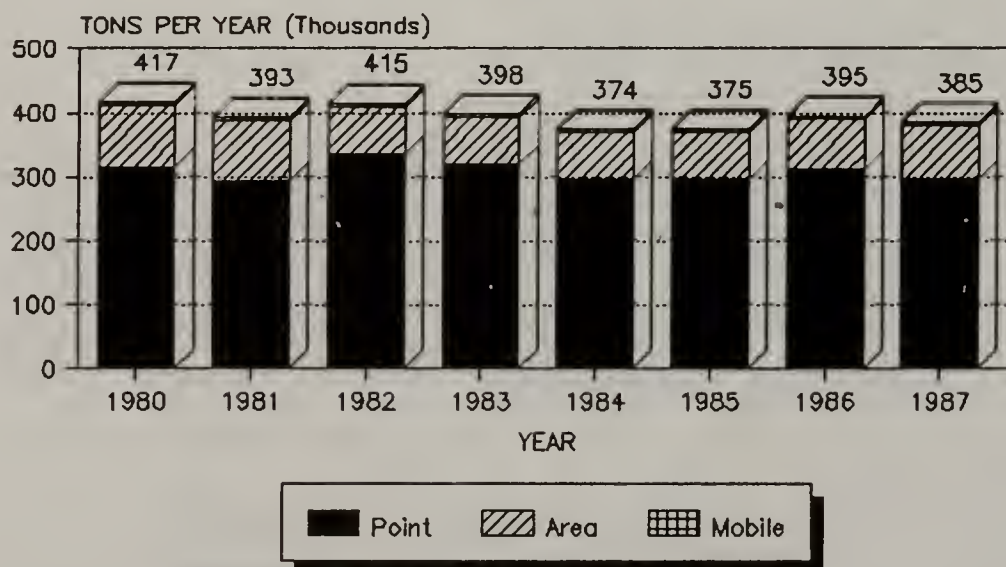
Data Source: DEP/DAQC "Massachusetts  
 Demonstration of Reasonable Further  
 Progress - Carbon Monoxide"; 1988

# 1980 TO 1986 STATEWIDE NITROGEN OXIDES EMISSIONS FROM UTILITY, POINT, AREA AND MOBILE SOURCES



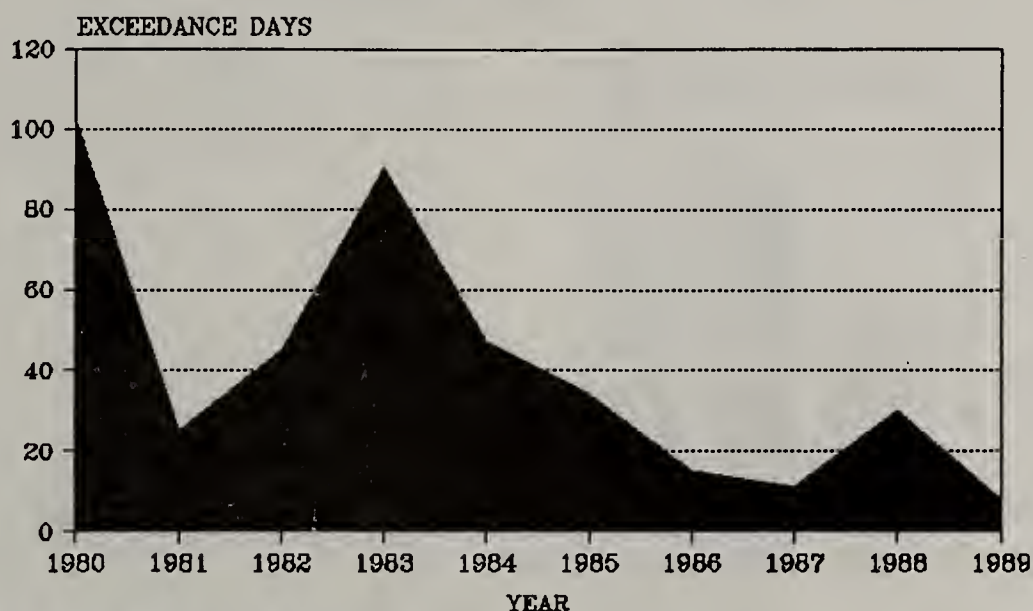
Data Source: DEP Division of Air Quality  
"Nitrogen Oxides Emissions Inventory -  
1980 to 1986"

# 1980 TO 1987 STATEWIDE SULFUR DIOXIDE EMISSIONS FROM POINT, AREA AND MOBILE SOURCES



Data Source: DEP Division of Air Quality  
"Sulfur Dioxide Emissions Inventory -  
1986 and 1987"; January 1989

## 1980 TO 1989 STATEWIDE OZONE EXCEEDANCE DAYS PER YEAR



Data Source: DEP Division of Air Quality  
"Massachusetts Demonstration of Reason-  
able Further Progress - Ozone"; 1988

control might be needed. Long-term monitoring helps to characterize air quality conditions over the diverse range of meteorological and emission conditions. DEP recently positioned three remote monitoring sites located away from stationary pollution sources in order to detect pollution due primarily to long distance transport. A second extension of monitoring capability has been directed toward specific, non-criteria toxic contaminants. New sophisticated monitoring technology is located at three stationary toxics monitoring sites and in a mobile laboratory. This mobile lab can respond to emergency air pollution conditions and conduct short-term special studies virtually anywhere in the Commonwealth.

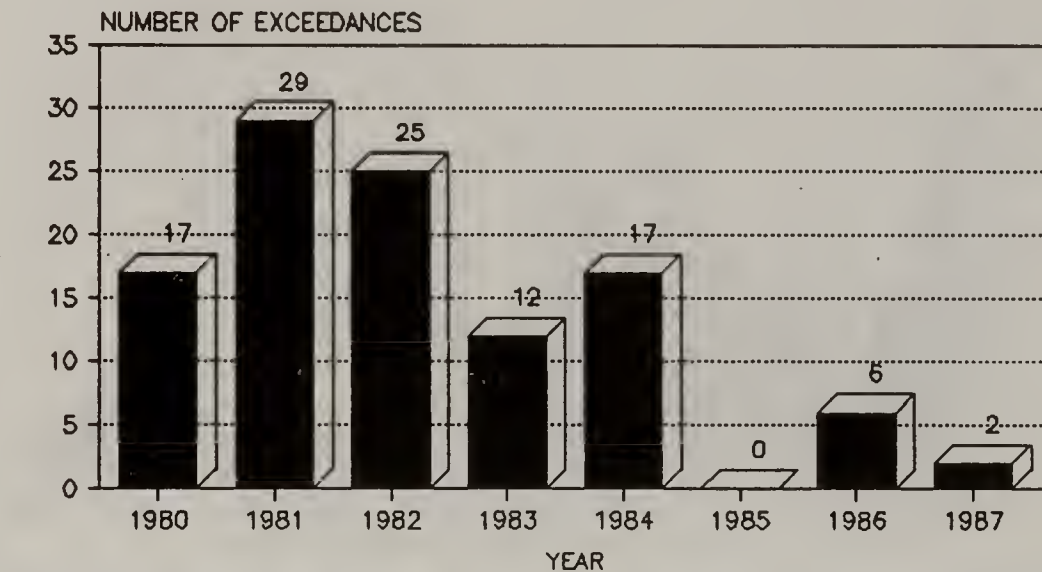
Massachusetts is in compliance with the National Ambient Air Quality Standards for lead, particulates,  $\text{SO}_2$ , and  $\text{NO}_x$ . Portions of the state exceed the

CO standard (the urban areas of Boston, Lowell and Springfield) although monitoring records show fewer problems than a decade ago. The entire state is considered to be non-attainment for ozone, although the number of exceedences has generally decreased since 1980. Ozone formation is highly dependent on weather conditions. A summer that is hot and sunny will usually be a summer of poor air quality. The summers of 1983 and 1988 were very hot and dry and there were many exceedences, notwithstanding the steady decrease in the emissions of the ozone precursor pollutants.

### Trends

Massachusetts has made progress in the effort to clean the air. For some of the criteria pollutants there has been marked improvement. Airborne lead, for instance, has been significantly reduced,

### NUMBER OF MEASURED 8 HOUR EXCEEDANCES OF CARBON MONOXIDE STANDARD 1980 TO 1987



Data Source: DEP/DAQC "Massachusetts Demonstration of Reasonable Further Progress - Carbon Monoxide"; 1988

due to the reduction in use of leaded gasoline. Air quality is better today relative to  $\text{SO}_2$  than it was 20 years ago, due in large part to regulations requiring that lower-sulfur-content fuels be used. There are far fewer exceedances of the CO standard than there were 10 years ago, but congested areas still show problems. Particulate levels are lower than 20 years ago, but not much different over the last decade, as the major control effort was made in the early '70s.

## SURFACE WATER

It is evident from other sections of this report that Massachusetts has an abundance of surface water resources. Over 1,600 lakes and ponds cover more than 150,000 acres of the Commonwealth. Some 2,000 named rivers and streams flow for more than 10,700 miles. These resources are depended upon to meet many critical needs. Over 67 percent of

the Commonwealth's residents rely upon surface water for their drinking water supplies. Twenty-six percent of surface water use supports industrial purposes. Each year over 235,000 fishing licenses are purchased in Massachusetts and our surface waters are vital components of valuable wildlife habitat. Demand for water-based recreation is constantly increasing. The surface water resources of Massachusetts are subject to ever growing and competing demand.

## Pollutants and Sources of Stress

Early efforts to control water pollution concentrated on what are called conventional pollutants, defined primarily as oxygen-demanding substances, suspended solids and bacteria. From the mid-1960s, when public concern and support energized water pollution control efforts, to the early 1980s, the primary effort was to control these conventional

pollutants from both industrial and municipal sources. In this effort, over \$2.5 billion in federal, state, and local funds has been spent in Massachusetts on publicly owned treatment works (POTWs). In many instances, these plants represented the first controls on previously untreated discharges of sewage.

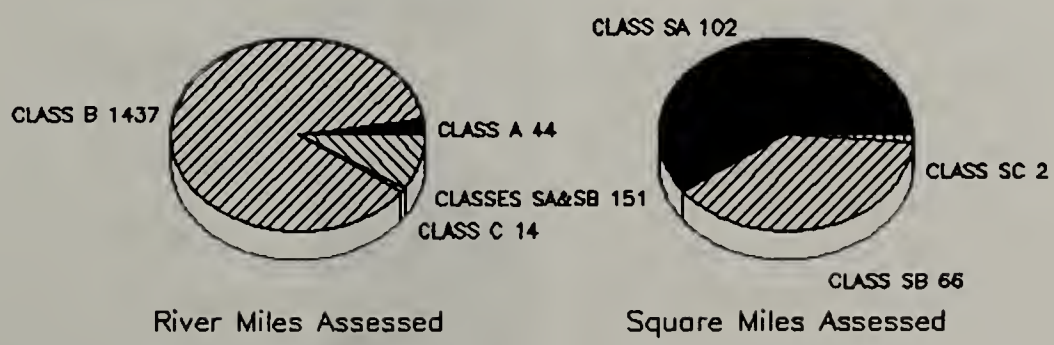
The focus of water pollution control has come to include evaluation and control of toxicity and toxic substances in effluents, excess nutrients and the effects of acid deposition. Chemicals like PCBs and mercury accumulate in fish tissue and can represent a threat to aquatic life, wildlife, and human health. PCBs are due solely to human activity, but mercury is due to natural processes as well.

Water quality classifications are designated in the document *Surface Water Quality Standards* which is up-dated by

DEP on a three year cycle. The standards contain criteria for several parameters for the various classifications for fresh and salt waters. Inland waters are classified as Class A (can be used for public drinking water supply), Class B (can be used for fishing and for primary and secondary contact recreation), or Class C (can be used for fishing and for secondary contact recreation). Coastal and marine waters are classified as Class SA (fishing, primary and secondary contact recreation, and shellfishing without depuration), Class SB (fishing, primary and secondary contact recreation, and shellfishing with depuration), or Class SC (for fishing and for secondary contact recreation).

The standards contain specific limitations for dissolved oxygen, bacteria, pH, temperature, and narratives for toxics, nutrients, aesthetics, radioactive substances, color, turbidity, total

### SUMMARY OF CLASSIFIED USES OF ASSESSED WATERS IN 1988 305B REPORT



Data Source: DEP "Commonwealth of Mass. Summary of Water Quality 1988"

suspended solids, and oil and grease. Recently proposed standards, if accepted, will contain specific criteria for color, turbidity, total suspended solids and many specific toxics. It should be noted that the classifications do not necessarily reflect the current condition of the waterbody, but represent a goal for that particular waterbody.

### Measures of Quality

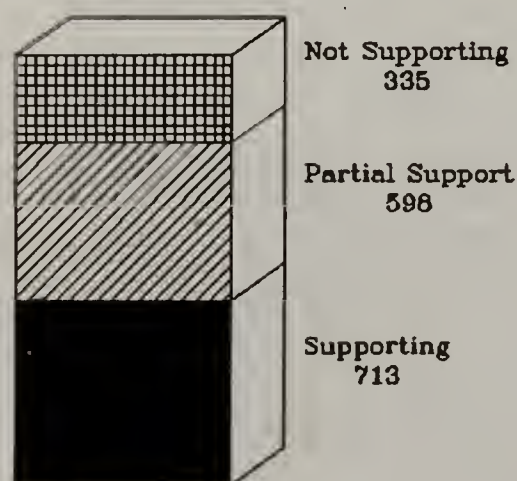
The surface water quality in Massachusetts has improved considerably since implementation of the 1972 Federal Water Pollution Control Amendments. In 1988, 43 percent of the 1646.1 river miles assessed and 32 percent of the 170.66 estuary square miles assessed fully supported their designated classification. Twenty percent of the assessed river miles and 3.5 percent of the assessed estuary square miles do not meet their classification. The remaining assessed river

and estuarian miles are in partial attainment of their designated classifications.

In rivers and estuaries, coliform bacteria are the leading cause of the partial and non-attainment status. Combined sewer overflows and municipal wastewater treatment plants are the major point sources, while urban runoff and failing septic systems are the leading non-point sources of bacteria contamination.

Causes of partial and non-attainment in river miles were found to be point sources (18.5 percent), non-point sources (20.3 percent), and both point and non-point sources (26.8 percent). Water quality effects from point sources are declining as a result of the construction and upgrading of wastewater treatment plants. Non-point sources, however, continue to degrade water quality and are more apparent now that the point sources

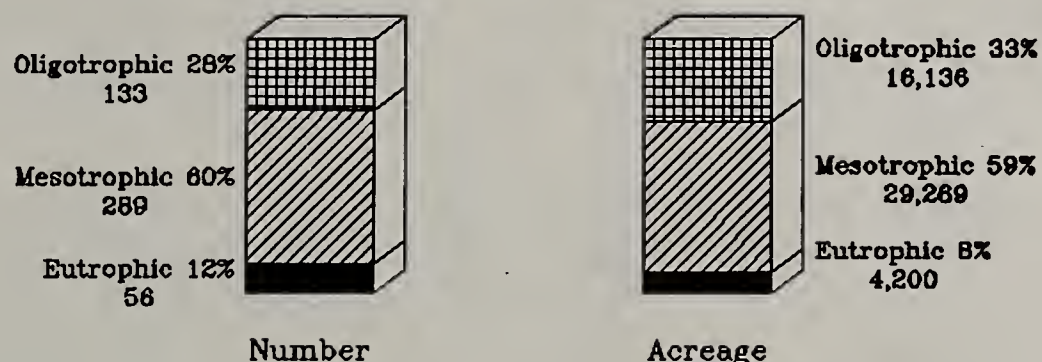
#### SURFACE WATER QUALITY ASSESSMENT RIVER MILES SUPPORTING DESIGNATED CLASSIFICATION



River Miles Assessed

Data Source: DEP "Commonwealth of Mass.  
Summary of Water Quality 1988"

## WATER QUALITY STATUS OF SURVEYED LAKES AND PONDS



Data Source: DEP "Commonwealth of Mass.  
Summary of Water Quality 1988"

have improved. The most damaging non-point sources include surface run-off from roads, farms, and other dispersed land uses such as faulty septic systems and landfills.

Eighty-eight percent of the lakes and ponds assessed meet oligotrophic status (low plankton productivity from a low input of nutrients) or mesotrophic status (higher rates of productivity, but not the extreme growth which occurs in eutrophic water bodies). However, of the 478 lakes and ponds assessed for the 1988 *Commonwealth of Massachusetts Summary of Water Quality (305 B Report)*, 136 (28.5 percent), were listed as threatened or impaired on the basis of eutrophic status. In lakes and ponds, the leading cause of eutrophic status is elevated nutrients from surface run-off and failing septic systems. These nutrients cause algal blooms and dense macrophyte growth, which further cause dissolved oxygen problems.

Toxic chemicals have been monitored in 60.7 percent of the rivers and 22.7 percent of the estuaries. Over 26 percent of the monitored rivers and 61.5 percent of the monitored estuaries are affected. One of the best indicators of the presence of toxics in surface waters is the concentration of contaminants in fish tissue. In order to assess this issue, an effort was initiated several years ago by the Massachusetts Division of Fisheries and Wildlife and the DEP Division of Water Pollution Control to monitor the concentrations of selected contaminants in edible fish tissue. The results indicate that several waterbodies contain fish that have contaminants in their tissue at sufficient levels to cause concern. Advisories have been issued against consumption or limiting consumption of fish caught in Quabbin Reservoir, Sudbury River, Ten Mile River, Copicut River, Lake Winthrop, Housatonic River, and

Millers River. These advisories remain in effect.

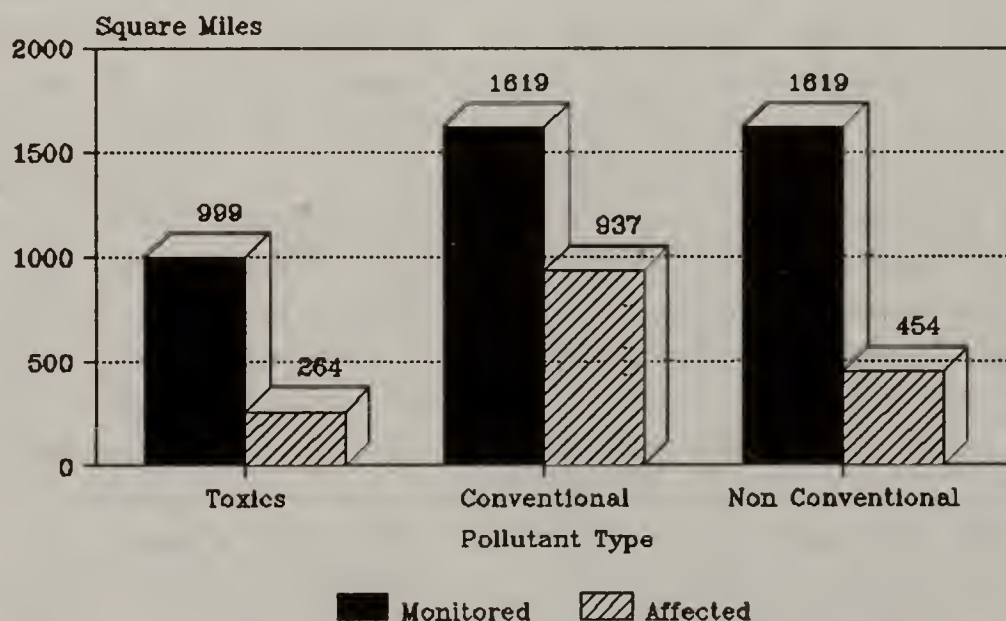
The monitoring data indicate that 92.2 percent of the river miles are fishable and 7.8 percent are posted with fish consumption advisories and bans. High levels of pollution in Boston Harbor have resulted in the elevated percentages of liver lesions, tumors and fin rot.

The monitoring data which support classification of surface water based upon acidity (pH) and alkalinity are provided by the Massachusetts Acid Rain Monitoring Project (ARM) at the University of Massachusetts at Amherst. Surface waters are classified into six categories based upon alkalinity (and to a limited extent pH, where those waters classified as acidified must have alkalinity  $\leq 0$  and a pH  $\leq 5.0$ ). The six classifications are acidified, critical, endangered, highly sensitive, sensitive and

not sensitive. During 1983 - 1985 ARM sampled 3370 surface waters and found that 5.5 percent were acidified, 16.8 percent critical, 20 percent endangered and 21.7 percent highly sensitive. Northern Worcester County and southeastern Massachusetts are the most sensitive and have the highest percentage of acidified, critical and endangered surface waters.

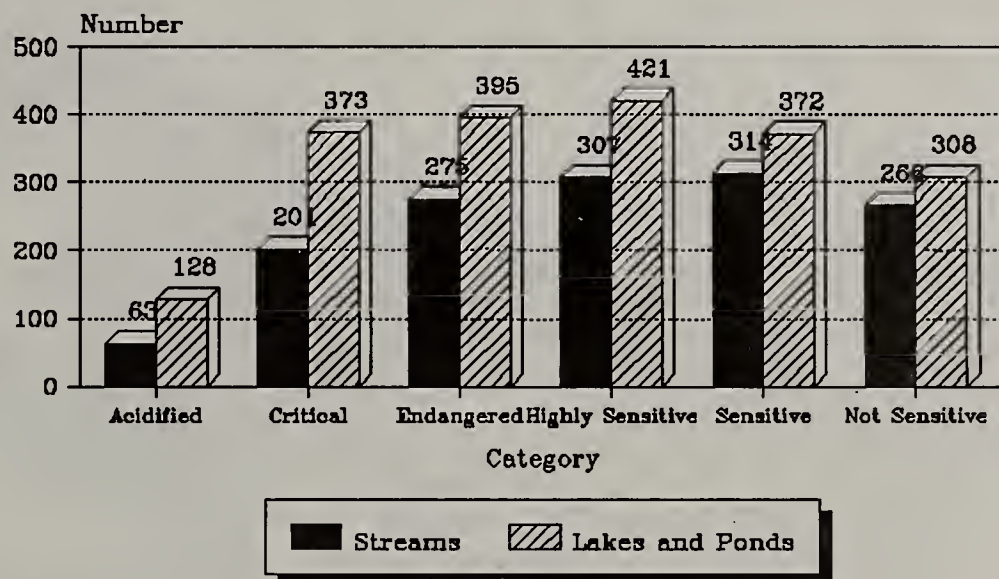
The Acid Rain Monitoring Project has continued to collect samples twice each year (April and October) for a stratified random sample of 800 surface water bodies, approximately 20 percent of the total number. These samples are analyzed for acidity, alkalinity and several trace metals. The results indicate no significant changes in mean pH or alkalinity on a state-wide basis over the

### ASSESSMENT OF RIVER STATUS FOR TOXIC AND NON-TOXIC POLLUTANTS



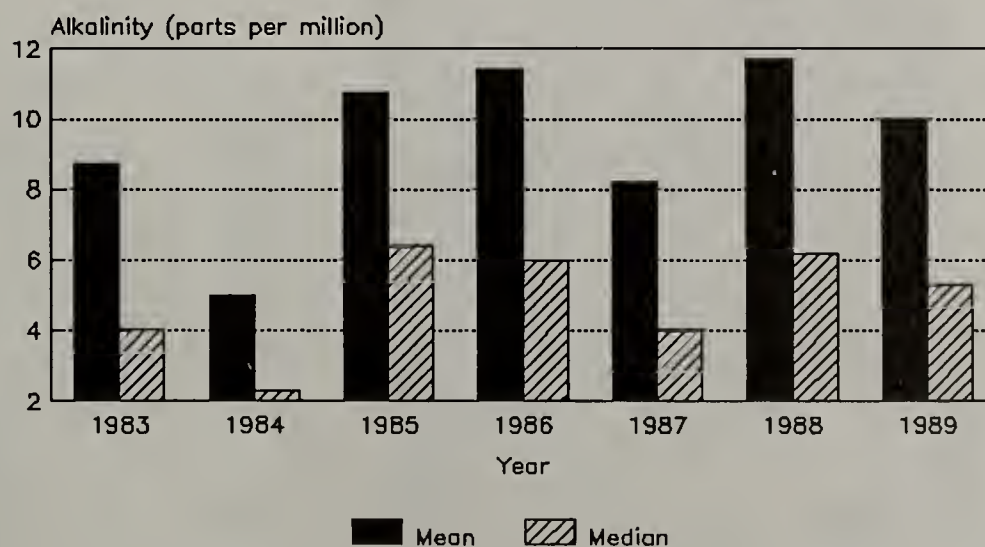
Data Source: DEP "Commonwealth of Mass.  
Summary of Water Quality 1988"

# STATUS OF MASSACHUSETTS SURFACE WATERS RELATIVE TO ACID NEUTRALIZING CAPACITY (ANC) 1983 TO 1985



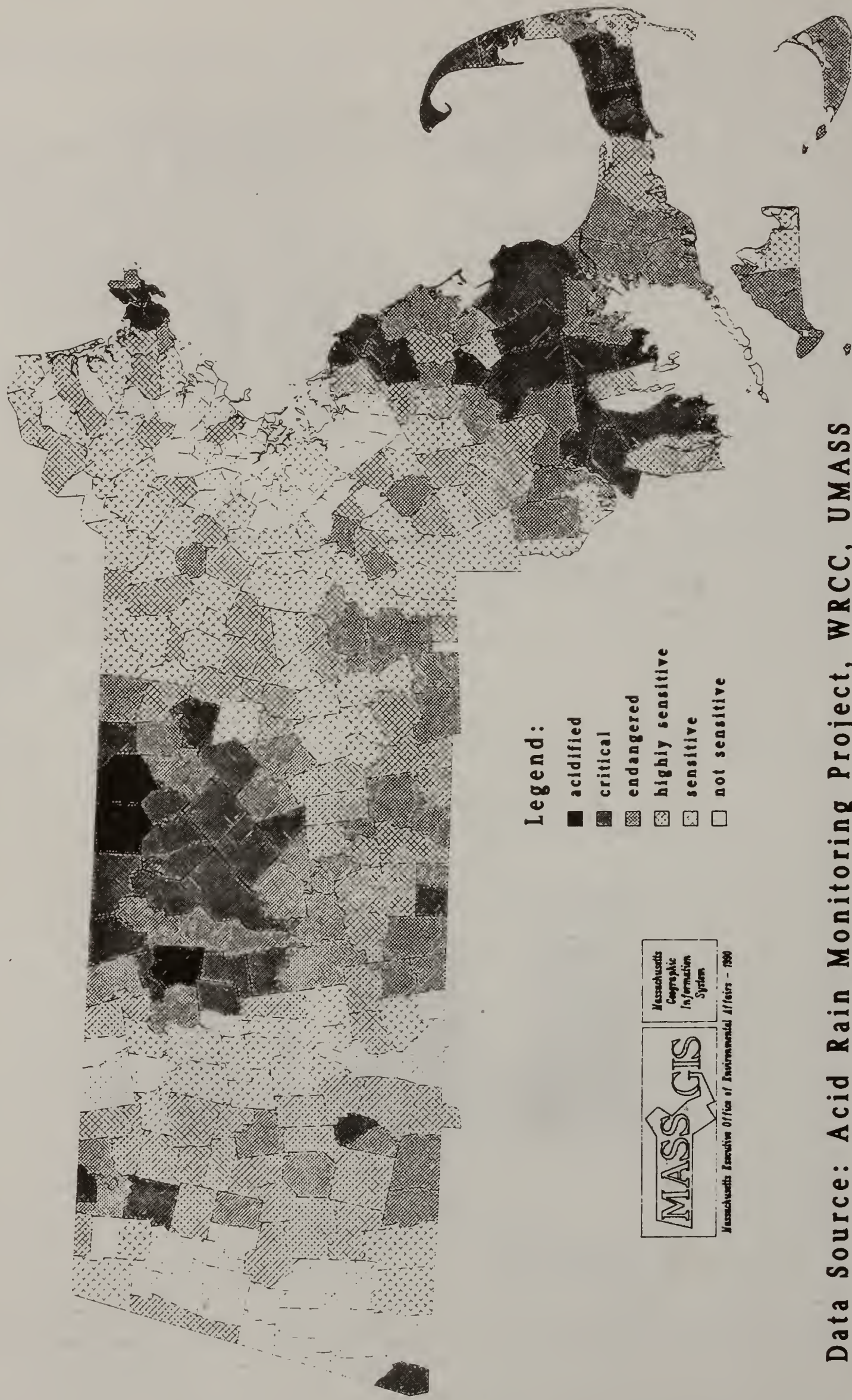
Data Source: Acid Rain Monitoring  
Project, Univ. of Mass., Amherst

# ALKALINITY OF MASSACHUSETTS SURFACE WATERS APRIL VALUES 1983 - 1989



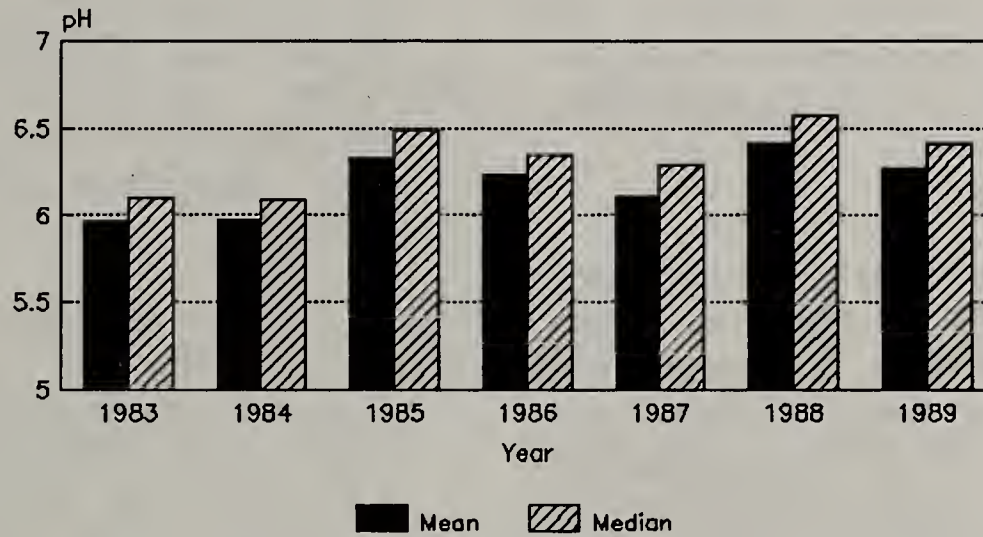
Data Source: Univ. of Mass.  
A.R.M. - Stratified Random Sample  
maximum sample size = 471

# Mean Alkalinity by Town of Massachusetts Surface Waters



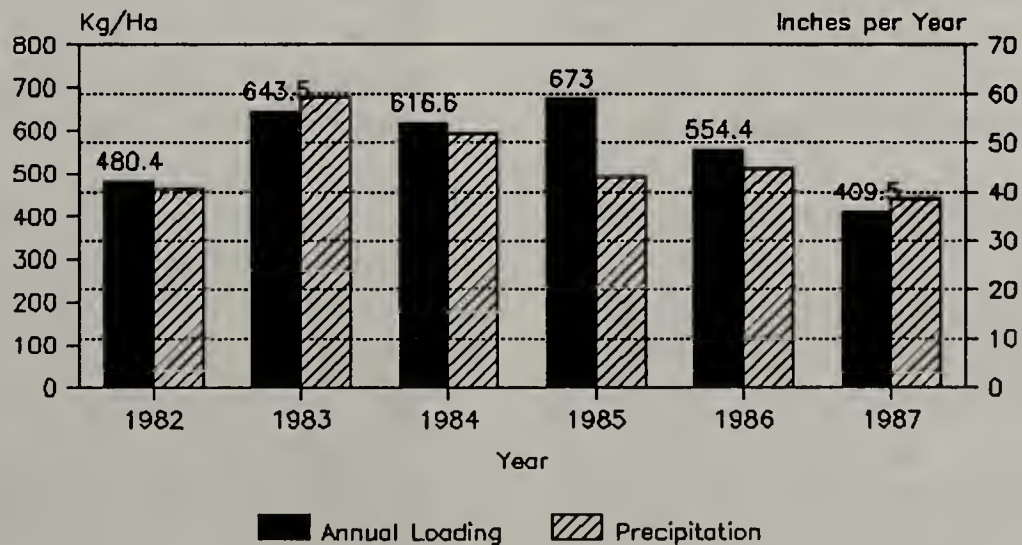
Data Source: Acid Rain Monitoring Project, WRCC, UMASS

# pH OF MASSACHUSETTS SURFACE WATERS APRIL VALUES 1983 - 1989



Data Sources: Univ. of Mass.  
A.R.M. - April Values  
maximum sample size = 471

# ANNUAL PRECIPITATION AND WET DEPOSITION CALCULATED AS HYDROGEN ION LOADING FOR MASSACHUSETTS - 1982 to 1987



Data Source: Acid Rain Monitoring  
Project, Univ. of Mass. and National  
Acid Deposition Program

past seven years and without reference to the classifications (acidified through not sensitive) listed in the previous paragraph. It therefore appears that the relatively small decreases in wet deposition, as indicated by data on hydrogen ion loading, have not resulted in significant improvements in surface water quality.

## **Trends**

Surface water quality has improved relative to conventional pollutants (oxygen demanding substances, suspended solids and bacteria) over the past 18 years. The construction of waste water treatment plants is responsible for this improvement. In 1972, 16 percent of our rivers met the standards as fishable and swimmable; today, it is close to 50 percent. On the other hand, pollution due to excess nutrients, especially from non-point sources, is perceived by the Department of Environmental Protection as an increasing problem. This is due, in large measure, to rapidly change land use.

Very little data exist concerning toxics in sediments or surface water. Those data that do exist do not present sufficient evidence of any trend, though it is assumed that, due the such programs as NPDES permitting, inputs of toxic pollution have declined significantly.

The information on acidification of surface waters is also not extensive enough (in time) to provide any clear trend. Evidence does seem to indicate that significant reductions in acid deposition can be expected to lead to improvement in surface water acidity and alkalinity.

## **GROUNDWATER**

The Commonwealth has over

810,000 acres classified as medium- and high-yield aquifers, 16.2 percent of the entire area of the state. These aquifers are not evenly distributed throughout the state. Cape Cod, the South Shore and the Connecticut River Valley show the highest ratio of aquifers to land area. Upland regions of the state, while containing many lower-yield aquifers, have fewer significant yield groundwater resources.

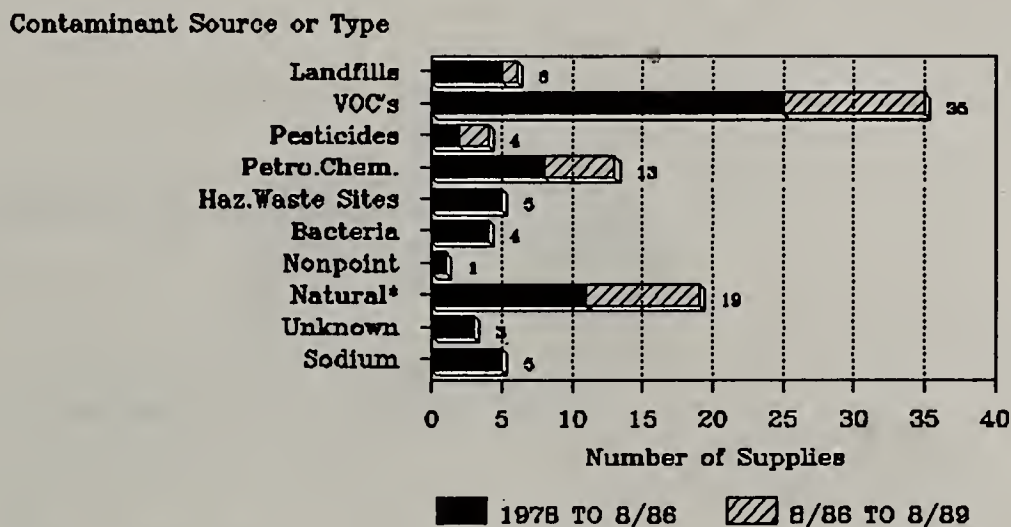
These resources must be carefully managed. One third of the population depends upon groundwater to meet water supply needs. Fifty-five percent of all communities are totally dependent on groundwater and 24 percent use a combination of groundwater and surface water. Seventy-six percent of industries in Massachusetts rely on groundwater for manufacturing and cooling.

## **Pollutants and Sources of Stress**

There are many sources and types of groundwater contamination, both natural and artificial. Disposal practices for wastewater, solid wastes and hazardous wastes are the most serious sources of groundwater pollution. Contamination is also a result of hazardous waste spills and leaks, the use of road salt, pesticide use and biological contamination.

The major contaminant group responsible for groundwater contamination is volatile organic compounds or VOCs. VOCs by their nature are light in weight and easily dissipate into the air. They also percolate into and travel with groundwater quite readily. VOCs are commonly found in industrial and household degreasers, drycleaning solvents, and petroleum products. Contamination results from poor industrial waste management and, to a lesser yet

# PUBLIC WATER SUPPLIES CLOSED BY SOURCE OF CONTAMINANT 1978 TO 1989



Data Source: DEP Division of Water Supply. \*includes Iron, Manganese, etc.

significant degree, household wastes. Leaking underground storage tanks contribute significantly to the problem. There are an estimated 50,000 underground storage tanks throughout the state, of which about 20 percent leak each year.

VOCs can cause serious health effects in humans and animals. Exposure at high levels has been shown to result in a variety of acute and chronic toxic effects in animals. These levels, however, are usually much higher than those found in public drinking water. Damage to the liver and kidneys, cardiovascular changes and central nervous system depression are results of high exposures to VOCs. Many VOCs are also suspected carcinogens.

Pesticides are another group of contaminants found in groundwater in agricultural areas of the state. Most pesticides and herbicides are organic

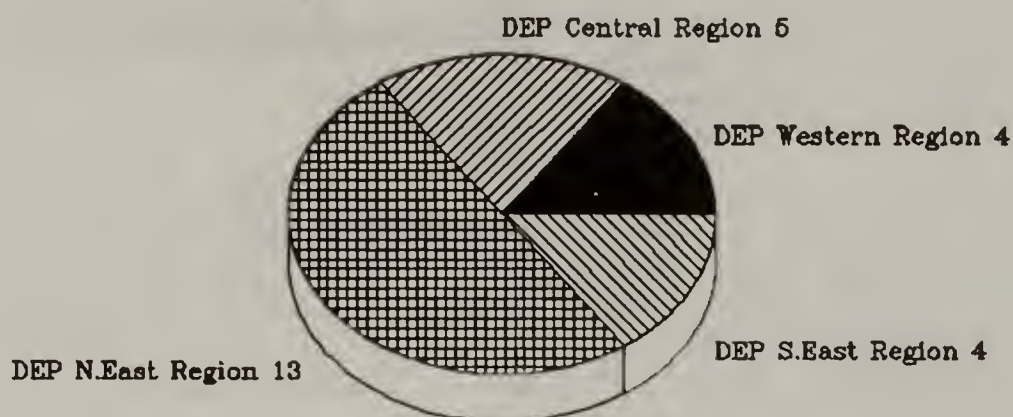
compounds and have many of the same harmful effects as VOCs.

Since World War II the use of sodium chloride (road salt) as a deicer has steadily increased. Road salt is relatively inexpensive. As the primary source of sodium contamination in water supplies, however, mitigation expenses outweigh the initially low costs. This type of contamination has resulted in the closure of many private wells and is also threatening several municipal supplies.

Substantial medical evidence indicates that sodium taken in excess of physiological need results in high blood pressure. It can also contribute to heart disease and kidney and liver ailments. British studies have implicated sodium as a factor in the phenomenon of Sudden Infant Death Syndrome.

While quality has always been an

**LOCATION OF PUBLIC WATER SUPPLIES  
CLOSED DUE TO CONTAMINATION  
8/86 TO 8/89**



Data Source: DEP Division of  
Water Supply

important consideration in managing water supplies, quantity has recently become just as important. Groundwater contributes significantly to surface water bodies because the two sources are part of a single hydrologic system. The groundwater table stores water and releases it slowly to the surface during dry periods. Excessive demands for water can cause both surface and groundwater sources to be overdrawn.

Increasing demand for groundwater withdrawals results from growing consumption rates for existing homes and businesses as well as new residential, commercial and industrial development. Excessive withdrawals can lead to the depletion of groundwater resources at rates faster than they can be replenished from rainwater percolation through the soil. In some coastal communities, excessive withdrawals can draw saltwater into the aquifer (saltwater intrusion).

Wells running dry and the destruction of wetlands and surface water bodies are also caused by excessive withdrawals.

### Measures of Quality

Massachusetts is a highly industrial state and has been for 150 years. Contaminants enter the groundwater from land surfaces where they have been dumped, spilled or released and percolate down to the water table. As of October 1986, public water supplies in 48 communities had been closed as the result of contamination. Since then, an additional 26 supplies have been closed primarily due to inappropriate land uses in primary recharge areas and accidental releases of oil or hazardous material. In addition, 636 private wells in 120 communities have also been contaminated. Nine communities have closed public or private wells due to fuel contamination from leaking underground tanks.

Public groundwater supplies providing more than five million gallons per day have been closed, as well as over 60 private wells, as a result of pesticide contamination.

## **Trends**

Trends in contamination of groundwater resources are difficult to determined based on the information analyzed for this report. Drinking water quality standards are frequently revised, which presents problems in detecting trends. However, the number of cases in which those standards are exceeded appears to be on the rise, and the risks to groundwater posed by underground storage tanks and releases of hazardous materials are substantial. There are an estimated 50,000 underground storage tanks in Massachusetts and as many as 20 percent of them may leak each year.

The 1974 Safe Drinking Water Act required public water suppliers to monitor for contaminants. Amended in 1986, the Act placed many more requirements on suppliers, such as stricter maximum contaminant levels for existing regulated contaminants, requiring monitoring for many more parameters and more stringent water treatment.

## **MARINE WATER QUALITY AND FISHERIES**

The most prominent feature of the Massachusetts coast is the diversity of its habitats which support a rich and varied marine community. The beaches, dunes, mudflats, tidal streams, wetlands and marshes, barrier beaches, estuaries and rocky shores provide spawning areas, nursery grounds and homes for

commercially important fish and shellfish and the lower-level food web organisms that support these populations.

The Commonwealth is adjacent to one of the most productive fishing grounds in the world, Georges Bank. Current state landings from offshore and inshore constitute 7.7 percent of the entire value of United States annual fishery landings.

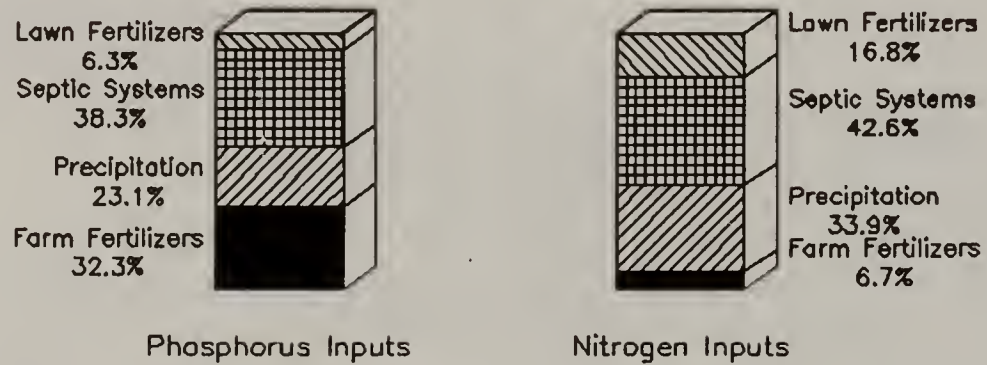
These same waters that provided for recreation, food and transportation have become the repository for human and industrial wastes. Today we are facing complex problems that are the result of neglect or abuse of coastal waters and fisheries and which threaten some of our most-valued resources.

## **Pollutants and Sources of Stress**

Defining pollution and its effects on the marine environment is not simple. Boston Harbor and some of our other industrial cities and ports have the reputation of being among the most polluted in the nation. The communities in southeastern Massachusetts are experiencing unprecedented growth and are facing degradation of near-shore environments through pathogen contamination and eutrophication of estuarine and near-shore waters.

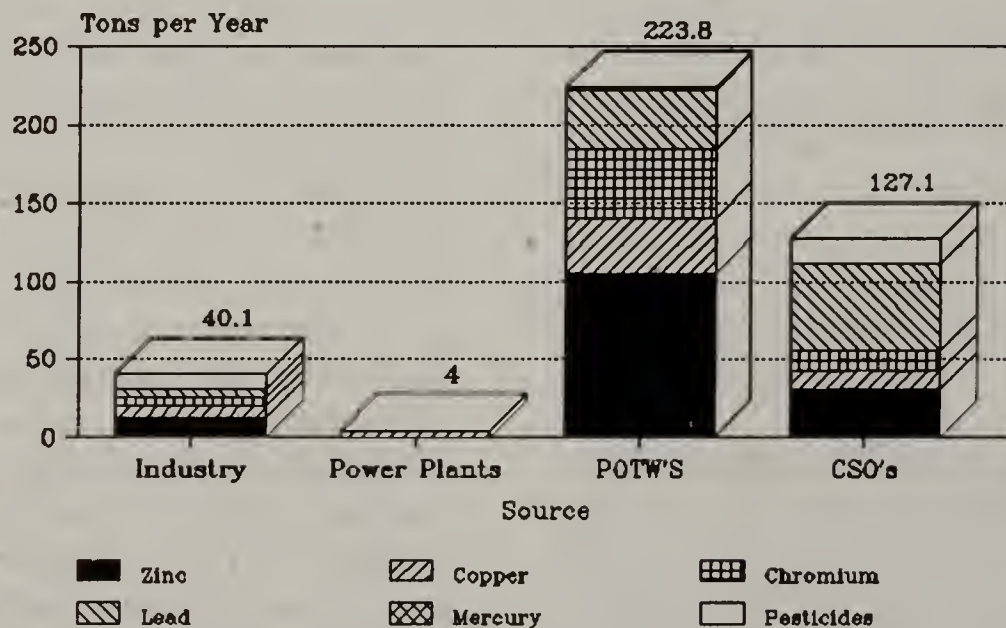
Several categories of pollution have been identified and are being monitored. These categories include coliform bacteria which are used as indicators of pathogen contamination; trace metals and organics which find their way into seafood and may cause health problems, disease or reproductive failure; nutrients which may lead to eutrophication; biological oxygen demand which, at high levels, depletes oxygen and may cause massive fish kills;

## MEASURED ANNUAL NITROGEN AND PHOSPHORUS INPUTS INTO BUTTERMILK BAY, BUZZARDS BAY



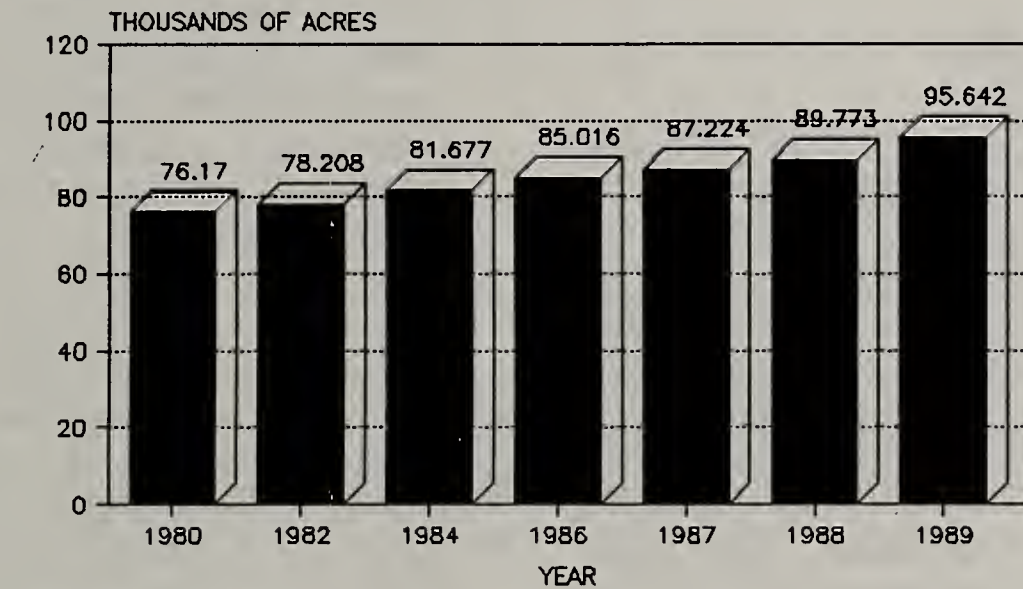
Data Source: Valiela and Costa, 1987

## ESTIMATED CONTRIBUTIONS BY SOURCE OF TOXIC LOADING TO BOSTON HARBOR



Data Source: Mass. MWRA, 1989

# TOTAL MASSACHUSETTS ACREAGE CLOSED TO SHELLFISHING 1980 TO 1989



Data Source: Mass. Division of Marine Fisheries

and total suspended solids which may smother bottom-dwelling communities and decrease plant production.

Contaminants such as trace metals and organics attach to particles and are deposited in sediments where they may be available to organisms and ultimately to humans through edible seafood. We are fortunate that such pollutants have to date caused only local problems with finfish, shellfish and lobster, primarily in New Bedford and Boston Harbors. Principal contaminants are PCBs and heavy metals from industrial sources.

Of concern is the extent to which humans are exposed to contaminants from eating seafood containing either the compounds themselves or their by-products. Although this link is still unclear, we do know that seafood from harbors has higher concentrations than seafood from relatively pristine areas such

as Georges Bank. Fortunately, most of our finfish come from offshore. An exception is lobster which migrates off and on shore. PCB contamination has resulted in a health advisory curtailing consumption of lobster from Quincy Bay and a total ban on fish consumption from New Bedford Harbor.

Over-fishing is a problem which has been exacerbated by the World Court decision in 1984 which excluded New England from thousands of square miles of traditional fishing grounds on Georges Bank. This, in turn, has placed our inshore fishing stock in greater jeopardy because of increased pressure from large offshore trawlers. Resource assessment surveys in state waters reflect the same general trends as offshore fisheries. The rapid and unchecked expansion of the New England offshore fleet has doubled the number of fishing vessels from 700 to 1,400 in 10 years. The technological

advance in fishing gear, electronics and fishing methods has increased the fishing power of new vessels, compounding the effects of increased fleet size and fishing effort.

## Measures of Quality

Measures of pollution affecting shellfish tell us about both water quality and the quality of an important fishery resource from the perspective of its suitability for human consumption. Shellfish landings declined from 449,000 pounds in 1987 to 282,000 pounds in 1988. Since 1980, the total number of shellfish bed closures from bacterial contamination has increased 25.6 percent. Total acreage closed has increased from 76,170 in 1980 to 95,642 in 1989. This translates to an estimated annual economic loss of \$94.5 million and the need to import 75 percent of shellfish consumed in the state. On Cape Cod alone, shellfish closures have increased from 421 acres in 1970 to 7,516 acres in 1989. This appears to be a direct result of virtually uncontrolled development, nonpoint source pollution, and improper and illegal domestic waste disposal in our coastal areas. North of Cohasset all shellfish beds are permanently closed or restricted to master clam diggers who take the shellfish to depuration plants for cleansing before market distribution. These closures are due to combined sewer overflows which are still discharging raw sewage into receiving waters and storm drains which have numerous illegal hookups.

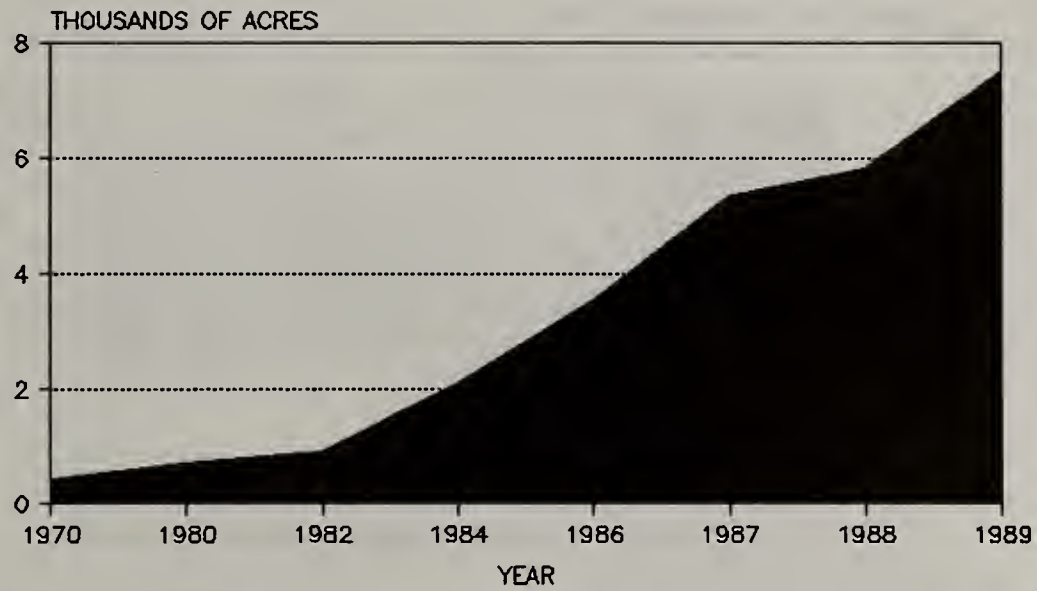
Contaminants such as lead, mercury, chromium, zinc, copper and other trace metals are concentrated in marine sediments around urban centers. Data presented here show the mean values of lead and other trace metals

from four separate studies of sediment from Boston Harbor. Organic pollutants, which include petroleum hydrocarbons (oil and grease), and one of their components, the polycyclic aromatic hydrocarbons (PAHs), enter the system through sewage treatment plants, road run-off, storm water run-off, combined sewer overflows and the atmosphere. Some of these organic compounds are correlated with acute toxicity (mortality), disease, or reproductive failure and are either degraded by marine organisms to more-or-less toxic compounds, excreted or accumulated. An assessment of 170 square miles of estuaries for the 1987 305B Report to EPA showed that 105 square miles were affected by conventional pollutants (solids and bacteria) and 17 square miles by non-conventional pollutants (nutrients). An assessment of 39 square miles of estuaries for the same report showed 16 of those miles affected by toxics.

Measures of contaminants in fish tissue, in addition to the public health implications, are useful indicators of marine water quality. The muscles of lobsters have low levels of contaminants, but the tomalley or hepatopancreas bio-accumulates trace metals, petroleum hydrocarbons and other organics such as pesticides and polychlorinated biphenyls (PCBs).

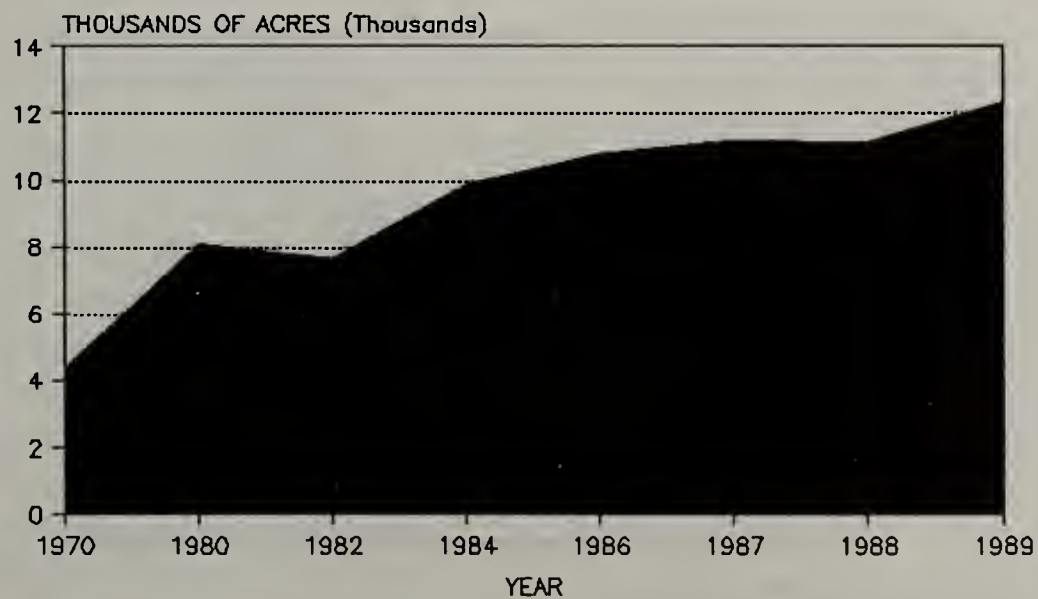
In areas with secondary treatment plants, biological oxygen demand (BOD) has been decreased nationwide. However, in Massachusetts the majority of the coastal population is still being served by antiquated primary sewage treatment facilities that contribute raw sewage when the systems fail. Major sources of total suspended solids are riverine input, particulates from storm drains, combined sewer overflows and sludge and dredging

# TOTAL CAPE COD ACREAGE CLOSED TO SHELLFISHING 1970 TO 1989



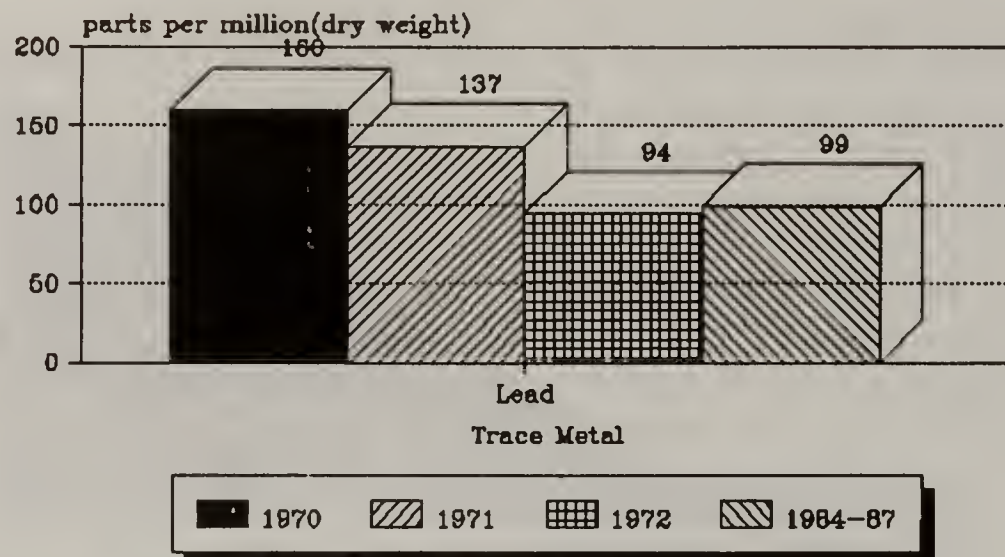
Data Source: Mass. Division of  
Marine Fisheries

# TOTAL BUZZARDS BAY ACREAGE CLOSED TO SHELLFISHING 1970 TO 1989



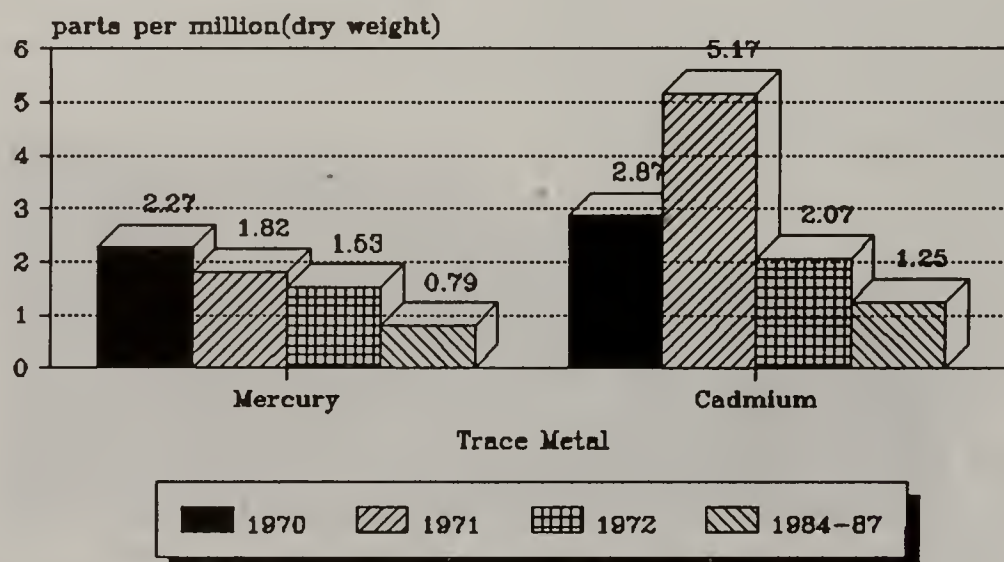
Data Source: Mass. Division of  
Marine Fisheries

# MEAN VALUE OF LEAD IN BOSTON HARBOR SEDIMENT 1970 TO 1987



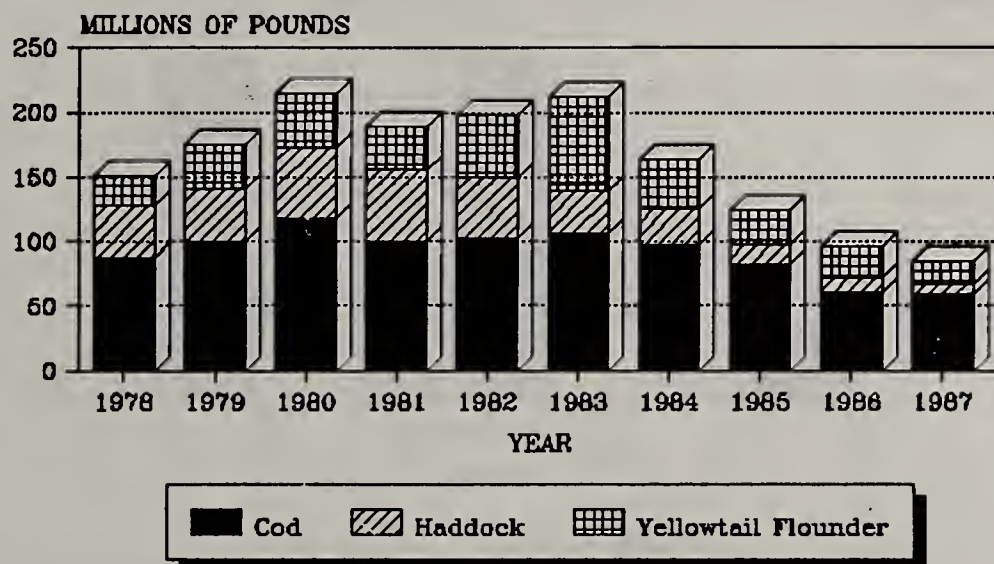
Data Sources: White(1972); Gilbert et al. (1972); Isaac and Delaney(1972); NOAA National Status and Trends.

# MEAN VALUE OF TRACE HEAVY METALS IN BOSTON HARBOR SEDIMENT 1970 TO 1987



Data Sources: White(1972); Gilbert et al. (1972); Isaac and Delaney(1972); NOAA National Status and Trends.

# MASSACHUSETTS LANDINGS OF COD, HADDOCK AND YELLOWTAIL FLOUNDER 1978 TO 1987



Data Source: NMFS Fisheries Statistics Reports

projects which resuspend sediments. The Massachusetts Water Resources Authority treatment facility that serves over two million people as far west as Framingham, north to Nahant and south to Quincy will cease dumping sludge by January 1991. Nonetheless, even with secondary treatment, particulates, associated trace metals, organics and nutrients are still discharged into the environment.

In spite of our enviable position in relation to other states, the fishery resources off our coasts and inshore are declining at an accelerating rate. Spawning stocks of haddock have declined from 120,000 metric tons in the 1960s to less than 20,00 metric tons today. Cod and yellowtail flounder show similar alarming trends. Management measures aimed at increasing fish stocks have not worked.

The inshore lobster fishery

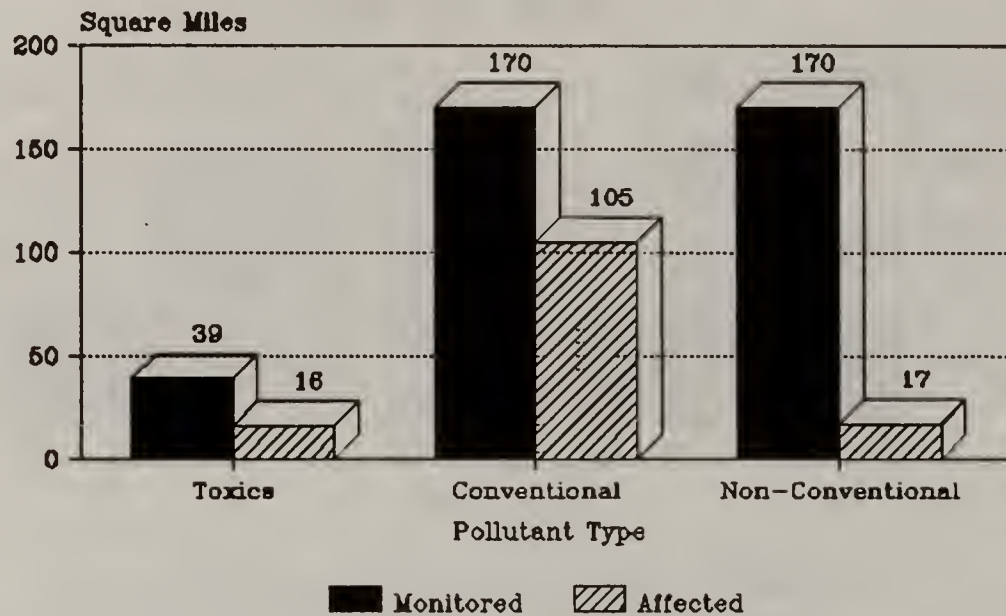
continues to increase landings by fishing greater numbers of traps in spite of a moratorium on the number of fishing licenses. Greater effort is now required to catch fewer lobsters per trap haul. The high landings do not reflect the precarious state of this over-capitalized fishery.

Recreational fishing has increased and continues to increase at dramatic rates. Although stocks remain at relatively high levels, bluefish stocks are showing signs of decline. Striped bass, at low levels for several years, are showing signs of population recovery. This is believed to be a direct response to intensive and comprehensive management.

## Trends

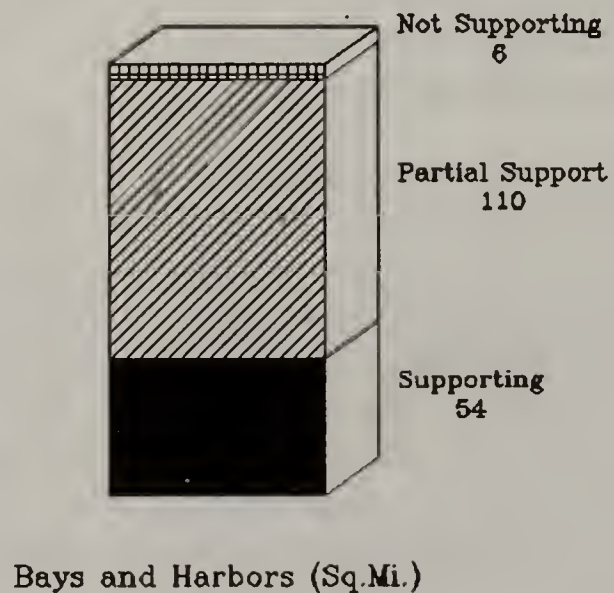
In some areas pollutants discharged to our near-shore waters are decreasing. Lead concentrations are lower as a result

# ASSESSMENT OF ESTUARY STATUS FOR TOXIC AND NON-TOXIC POLLUTANTS



Data Source: DEP "Commonwealth of Mass.  
Summary of Water Quality 1988"

# SURFACE WATER QUALITY ASSESSMENT ESTUARY MILES SUPPORTING DESIGNATED CLASSIFICATION



Data Source: DEP "Commonwealth of Mass.  
Summary of Water Quality 1988"

of regulations requiring the use of low-lead gasoline and concentrations of other metals and selected organics are lower where pretreatment programs are enforced or because some chemicals are no longer manufactured, e.g. PCBs and certain pesticides. Nonetheless, many chemicals are persistent, they do not degrade or break down in the marine environment. PCBs have not been manufactured since 1978, but PCB concentrations are still high in the sediments of affected areas and are accumulated in organisms such as the lobster. This has resulted in closing the lobster fishery outside of New Bedford Harbor. Lawn care companies use excessive amounts of herbicides and pesticides which are carried into storm sewers and rivers and eventually find their way to marine waters. These chemicals are not being monitored and it is not known to what extent they persist or are degraded.

There is some evidence that the marine environment is experiencing increases in pathogen contamination both as coliform bacteria and viruses. Nutrient loading, which is correlated with development, also appears to be increasing and continues to threaten near-shore environments by contributing to excessive plant growth which fouls waters and by contributing to nuisance algal blooms such as red tide organisms.

## **WETLANDS**

In the mid 1970s approximately 12 percent of the state's land area was covered by wetlands, an amount equal to 590,000 acres. Almost 80 percent of that wetland resource is freshwater palustrine (swampy) wetland. Forested wetlands account for 71 percent of palustrine wetlands and 56 percent of the entire resource. Twenty percent of wetlands are

estuarine and marine and the remaining .8 percent is lacustrine and riverine.

The acreage of wetlands lost in the past 12 to 15 years is impossible to determine, since no state-wide studies have been conducted which allow for estimation of recent wetland loss.

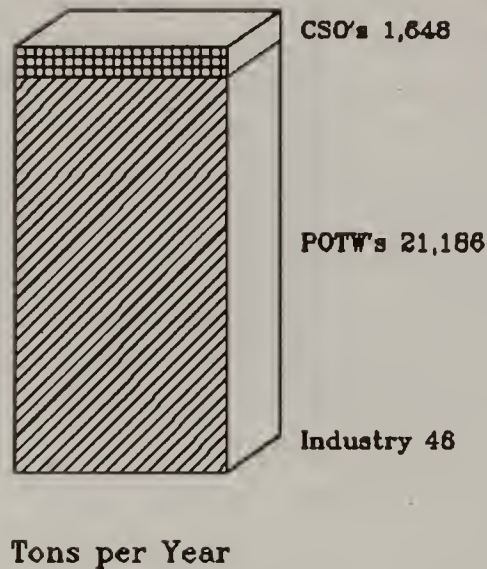
Wetlands perform many valuable functions which are described in detail elsewhere in this report. They are essential to almost all commercial and freshwater fisheries. They provide vital habitat for waterfowl and other birds, many game and non-game mammals, numerous other wildlife and many valuable plant communities. Wetlands are important elements in the hydrologic cycle. They store flood waters, prevent damage and remove excess nutrients. The functions they perform become increasingly critical as the number and acreage of wetlands lost increases.

## **Pollutants and Sources of Stress**

The pressure to develop land in and near wetland areas is increasing, especially in the central and western portion of the state. Due to the increased value of land, areas that were once considered to be unsuited for development are now being reassessed. Since 1978 there have been over 51,000 permit applications (Notices of Intent) submitted to Conservation Commissions for work proposed in or near wetlands. During the past fiscal year, Commissions received over 8,800 Notices of Intent. An additional 9,000 applications are expected to be submitted during the 1990 fiscal year.

Major human sources of wetlands loss, according to the US Fish and Wildlife Service's National Wetlands

# ESTIMATED CONTRIBUTION BY SOURCE OF PETROLEUM HYDROCARBONS TO BOSTON HARBOR



Data Source: MWRA 1989

Trends Study (1983), include conversions to agricultural use, urban use, deep water, non-vegetated wetlands and other uses such as forestry. Major development activities associated with this loss include dredging and excavation, filling, draining, clearing, and flooding. Indirect causes of loss are sediment diversion by dams, deep channels and other structures; hydrologic alterations by canals, spoil banks, roads and other structures; subsidence due to extraction of groundwater. Other human activities, various forms of waste disposal and water pollution all degrade wetland quality.

## Measures of Quality

The original area of freshwater wetlands in Massachusetts, according to recent soil studies, was estimated at 818,000 acres or 16.5 percent of the state. If these figures are accurate, Massachusetts has lost over 42 percent of

its original freshwater wetland areas. Due to this loss of thousands of valuable acres of wetlands over past decades, the need to protect the remaining wetland resource areas in the Commonwealth is paramount. While some of this loss is due to natural causes, most wetland loss is probably due to human activity.

A 1978 study by the USDA Soil Conservation Service reported that Massachusetts loses .4 percent of its wetlands each year. A more recent (March 1988) study of southeastern Massachusetts analyzed wetlands and found that approximately one fifth of the land surface in southeastern Massachusetts is occupied by wetlands (80,734 acres of wetlands in 1985/86). A comparison of wetlands from 1977 to 1985/86 concluded over 1,800 acres of wetlands changed vegetatively from one wetland type to another and 1,307 acres of wetlands were destroyed, a .2 percent annual decrease.

The annual loss of vegetative wetlands was approximately 150 acres. Ponds, however, showed a net gain of 30 acres annually. Nearly half of the wetland loss was due to conversions for upland developments, about a third for cranberry bogs and another 18 percent became ponds or lakes.

## **Trends**

The Massachusetts regulations remain among the most strict wetlands protection laws in the country. With the issuance of the coastal wetlands regulations in 1978, the alteration of valuable saltmarsh areas has been all but eliminated. Since passage of revised inland wetland regulations in 1983, the alteration of vegetated wetlands along inland rivers and streams has been greatly reduced. Except in limited circumstances, these inland wetland regulations prohibit any alteration of wetlands greater than 5,000 square feet. For most projects that come before Conservation Commissions, smaller alterations of less than 5,000 square feet require replication on a one to one basis.

## **OPEN SPACE AND AGRICULTURAL LAND**

The New England landscape brings to mind historic village centers, picturesque town commons, beautiful beaches, forests, and broad open vistas of countryside. The common thread among all these images is open space of one type or another. To one person open space may describe a busy neighborhood playground. To another, open space may mean an old growth forest stand, far removed from civilization. Open space refers to all undeveloped lands that are set aside in their existing state by virtue of ownership or placement of a

conservation restriction.

Massachusetts has a long history of involvement in protection of open space. At the turn of the century Mt. Greylock, located in the northwestern part of the state, was acquired and eventually became the first state reservation. At 3,491 feet in elevation Mt. Greylock, the highest point in the state, provides scenic views over a four-state area and is itself a prominent feature in the landscape. Mt. Greylock represents the first of many open space acquisitions and conservation restrictions across the state by all levels of government and many nonprofit land conservation organizations. According to the 1988 Statewide Comprehensive Outdoor Recreation Plan (SCORP) report, over 1.1 million acres of protected open space were documented, 21.2 percent of the Commonwealth.

This acreage is an invaluable asset in one of the nation's most densely populated states. It includes everything from mountain summits, forests, and sandy beaches to parkways, agricultural fields, and town playgrounds. These lands represent an investment in the future of Massachusetts and the opportunity for our children to experience the land in some of the same ways as the generations that preceded us. Protected open space, as wilderness and as smaller parcels intermingled with developed land, serves to safeguard those natural systems essential for mitigating pollutants that would otherwise make air unbreathable and water undrinkable.

While there are certain types of land resources that are universally important to protect regardless of where they occur, such as wetlands, aquifer recharge areas and unique wildlife habitat, many types of open space are regionally

or locally significant. Freshwater ponds and lakes, certain rivers and streams, coastal beaches, mountain tops and trails are all examples of resources that vary in importance depending upon quality and location.

Agricultural land represents a special category of open space. While most agricultural land is in private ownership, its existence and protection carries many of the benefits associated with open space in public ownership. In addition, protection of agricultural lands preserves the Commonwealth's ability to produce high-quality agricultural products. The open vistas and diversity of landscape fostered by farming are synonymous with the beauty and scenic quality of many of the state's rural areas.

### **Pollutants and Sources of Stress**

Loss of open space is the result of many factors, including an increasing population, regional shifts in population between urban and rural areas, a decrease in the size of the average household, and changing economic realities. As the Commonwealth's population grew during the latter half of this century, housing stock was built to accommodate the need. This resulted in the conversion of large areas of open space to residential uses. In its publication "Losing Ground: The Case for Land Conservation in Massachusetts, 1987" the Massachusetts Audubon Society reports that over 112,000 acres of land were developed in Massachusetts between 1980 and 1986, and that 79 percent of that acreage was devoted to housing development.

Where at one time new growth was concentrated in urban centers, building now reaches across the Commonwealth into many previously undeveloped land

areas. The report cited above indicates that the highest percentage of growth is occurring on the Cape and Islands, in the Merrimack Valley, and in the greater Worcester area. It is clear that the fastest rates of development are occurring in resort areas and in rural and suburban communities outside existing developed areas.

The state's "prime" and "state-wide significant" agricultural soils are under siege, frequently targeted for development because they are easy and inexpensive to convert to residential and other non-agricultural uses. The Department of Food and Agriculture estimates that between 1967 and 1977, 300,000 acres, or 45 percent of the state's valuable agricultural land, were converted to non-farm uses.

### **Measures of Quality**

Two different efforts to document the extent and location of open space in the Commonwealth have been completed during the past three years. The first, the 1988 - 1992 SCORP report, has been discussed to some extent earlier in this report. The second effort, conducted by the Commonwealth's five environmental agencies in conjunction with EOE's MassGIS, a state-wide geographic information system, actually mapped all state, federal and private non-profit open space. Mapping of municipally owned open space has been completed for Essex and Berkshire Counties and the Nashua River Basin and is under way for Barnstable County.

SCORP provides listings for 1,104,024 acres of open space including all above-named categories plus private profit-making recreational land. The breakdown by ownership category is

# State and Federal Protected Open Space in Massachusetts



Data Source: EOEa agency open-space compilation

Massachusetts  
Geographic  
Information  
System



Massachusetts Executive Office of Environmental Affairs 1989

shown herein. SCORP shows some 488,975 acres under state ownership compared with 513,170 shown in MassGIS, a difference of 24,195 acres or 4.7 percent. That difference may be accounted for by varying definitions (i.e. SCORP does not include Agricultural Preservation Restrictions while MassGIS does) and by variations in area measurements (MassGIS calculates acreage by computer, SCORP relies of acreage as recorded in a deed).

Based on the SCORP survey of open space, 21.2 percent of the Commonwealth is open space under the ownership categories listed above. In those areas of the Commonwealth for which MassGIS has mapped essentially the same categories of open space (private for-profit lands are not included) the percentage of open space to total area is quite close to the state total as listed by SCORP. Berkshire County data show 25.8 percent of total land area as owned by public agencies and private non-profit organizations. Essex County is 20.2 percent open space and the Nashua River Basin is 22.6 percent. Other areas of the Commonwealth may not be nearly as well off but, until mapping of municipally-owned lands is completed, calculation of percentages and comparisons will not be possible.

## Trends

The rate and extent of land use change in the Commonwealth is discussed in some detail in Chapter II of this report, yet a few additional facts are worthy of consideration at this point. Population state-wide from 1950 to 1970 grew at a rate of 1.06 percent per year. Land, however, was being developed at an annual rate of 5.43 percent, over five times the rate of population growth. During that same period agricultural land

was being lost at an annual rate of 1.74 percent. Population growth between 1950 and 1985 was at an annual rate of .7 percent. In the five county study area discussed in Chapter II, residential land use grew at a rate of 7.45 percent during that same period, over 10.5 times the rate of population growth.

During the past decade the Commonwealth's environmental agencies have attempted to protect additional open space through acquisition and the use of conservation restrictions. Between 1980 and 1989, 58,815 acres were preserved through such measures, an amount equal to 11.5 percent of total open space under state ownership or restriction. Yet those acres, in comparison with the nearly 160,000 acres estimated to have been developed during the same period, represent only one acre protected for each three developed.

Over 25,000 of the acres protected in the past decade have come under the Agricultural Preservation Restriction (APR) Program established in 1977. The APR Program pays farmers the difference between the fair market value and the agricultural value of their farmland in exchange for a permanent deed restriction. The APR Program has protected 270 farmland parcels in 103 communities across the Commonwealth. The program's immediate objective is to permanently protect a total of 50,000 acres of prime farmland by 1993, including 10,000 acres of state-owned farmland. That amount represents a mere 4.7 percent of land in agricultural use in 1951.

The recent downturn in the state's economy, which has meant less in state revenue for land acquisition, may well result in a slowdown in the rate of

development at the same time. One recent trend of some concern is the increase in the number of applications being made by local communities to convert conservation and park land to other uses such as schools and affordable housing. Should land values continue to increase and public funds decrease, it can be expected that greater pressure will be placed on remaining open space of all types.

## FOREST HEALTH

It has been shown earlier (Chapters I & II) in this report that the forests of Massachusetts are important to both the economy and environmental quality. This important resource, like all natural resources, needs to be protected. Threats include air pollution, insects and disease. Researchers support with increasing regularity the theory that these agents often act in combination with one another leading to forest decline of varying degrees as a result of multiple stresses.

### Pollutants and Sources of Stress

The most important air pollutants affecting the forest are ozone and trace heavy metals. Other air pollutants less directly implicated in forest health are sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO), and nitrogen dioxide (NO<sub>2</sub>). SO<sub>2</sub> and NO<sub>2</sub> are two of the major contributors to acid deposition. Acid deposition and related air pollutants remain of major concern to forest health researchers even though specific effects on the forest are not well understood.

Besides air pollution, several forest tree diseases occur in the forests and urban shade trees of Massachusetts. In many instances, these diseases have similar symptoms to those induced by air

pollutants. The origin of these symptoms ranges from simple non-organic stresses such as drought or spring frost to complexes of fungi and insects. The major diseases currently causing symptoms and affecting the health of Massachusetts forests are Dogwood anthracnose, *Diplodia Pineae*, Beech Bark disease, Ash decline, and Maple decline. Historically, Chestnut blight and Dutch Elm disease have caused major changes to our forest and shade tree resource.

Numerous insect species cause injury to trees in the Commonwealth. Insects attack all parts of trees including foliage, shoots, cones, seeds, stems, and roots. Damage may be catastrophic, as when defoliation of hundreds of thousands of acres leads to decline and death of trees, or when the girdling activities of feeding bark beetles lead to extensive mortality. The major insects affecting the health of Massachusetts forests and shade trees are: Gypsy Moth, Pear Thrips, Oak Leaf Tier, Fall Cankerworm, Saddled Prominent, Brown Tail Moth, Two-lined Chestnut Borer, Nantucket Pine Tip Moth, Eastern Tent Caterpillar, and Forest Tent Caterpillar.

### Measures of Quality

Although we know that atmospheric deposition, air pollution, various insects and diseases affect the health of individual trees and stands of trees we do not know for certain what effects these localized or periodic problems have on the health of Massachusetts forests as a whole. Information provided through the USDA Forest Service Continuous Forest Inventory tells us only that saw timber stands have increased 61 percent from 1972 to 1985. In other words, we have

gained forest acreage and more trees are of sufficient size to warrant commercial harvesting. Such measures cannot be equated with over-all forest health, however, since these data fail to indicate the actual condition of the resource.

A complete aerial survey of Massachusetts forests in 1984 and 1985 showed 24,287 acres exhibiting signs of stress and decline with symptoms ranging from leaf discoloration, branch dieback and dead trees. Those stressed areas were concentrated in Bristol, Plymouth, Worcester and Berkshire counties. On-site examination of stressed areas indicated that insects and disease could account for most of the observed decline symptoms. Yet, some 2500 acres of red spruce and sugar maple in the Mt. Greylock area appeared to be experiencing damage due to acid deposition and related air pollutants. Nor can acid deposition and air pollution be eliminated as a contributing factor to decline in other areas of the state.

A 1987 ground survey of some 440 sugar maple trees at 22 sites throughout western Massachusetts found that only 24 percent were in relatively good health and 60 percent in relatively poor health. Subsequent field studies have shown that, for sensitive species including red spruce, norway spruce and sugar maple, forest decline is a significant problem in some areas of Massachusetts.

Forests are a conservative indicator of man's impact on the environment. The evidence collected in the Commonwealth so far suggests that the forests are changing, and this may be a result of chronic air pollution stress or acid deposition, or it may be a response to increased CO<sub>2</sub> concentrations in the atmosphere. The red spruce is a prime

example. Mortality rates are high and comparison of data from 1987 and 1988 shows significant deterioration of crown condition in just one year. Observations in 1989 show that a significant number of those trees have died since the beginning of the study. Other trees are showing similar symptoms although it appears some of them could rebound if pollution stress is reduced or eliminated. Many of the symptoms found are similar to those in West Germany for which there is evidence that air pollution is a primary factor.

The Gypsy Moth is probably the most widely known of insects because it has been in the news a great deal in the past few years. It lays its eggs on trees and the resultant larvae eat the leaves. This defoliates the trees and can kill them. The actual defoliation from the Gypsy Moth for Massachusetts in 1988 was 6,618 acres, as viewed from an aerial survey in July 1989. Although this figure is much lower than previous years (the total for 1987 was 116,007 acres and for 1986, 404,538 acres), it may be misleading since several areas throughout the state showed an increase in Gypsy Moth larval and egg-laying activity.

Pockets of significant defoliation occurred in Hampden, Hampshire, Franklin, Worcester and Middlesex Counties. Berkshire, Bristol and Norfolk Counties reported light defoliation throughout with increased larvae and egg production. Preliminary egg mass inspections and moth trap counts indicate a potential increase in Gypsy Moth activity in all counties except Worcester and Essex. Egg mass surveys in the Holyoke Range indicate the possibility of substantial defoliation in that area in 1990. The fungus *Entomophaga* reportedly helped reduce potential defoliation in

Middlesex, Berkshire and Worcester Counties.

The Pear Thrips is a recent arrival in the Commonwealth, first appearing in 1987. It also defoliates trees. The thrips was expected to cause serious defoliation in 1989 after causing 200,000 acres of defoliation in Berkshire, Hampden, Hampshire and Franklin Counties in 1988. As expected, the Pear Thrips adult females emerged from the soil in large numbers in the spring of 1989 throughout the state. Contrary to expectations little damage occurred to sugar maple foliage. Apparently the timing of insect emergence and bud development on sugar maples was different from that in 1988 so that little or no bud damage occurred in the bud stage. The only significant damage was in northern Berkshire County. There are, however, indications that this insect is moving eastward as far as the suburban metropolitan area and the North and South Shores.

The Oak Leaf Tier is found mostly in the southeast region of the state. It is also an insect that defoliates trees. In 1989 approximately 200,035 acres of forest in Massachusetts showed noticeable defoliation by a complex of Oak Leaf Tier and Oak Leaf Roller compared with 361,978 acres in 1988. The most widespread area of defoliation from these insects, ranging from light to moderate on individual trees and stands of trees, occurred in Bristol and Norfolk Counties. A small outbreak was also reported in Worcester County in the Auburn-Oxford area.

The Fall Cankerworm or "inchworm" attacks oak, cherry, ash, maple, hickory, beech and yellow birch trees. It defoliates the trees, leaving the skeletons of the leaves behind. It can

cause severe aesthetic damage to shade trees as well as mortality to both shade and forest trees. This insect caused significant defoliation in Falmouth, Scituate and Nantucket. A 1989 aerial survey of Cape Cod determined that approximately 2,000 acres were affected.

The Brown Tail Moth is found mainly on the Cape. This pest is not only destructive to host plants, but is also considered a health problem, as some people contract a severe rash from the caterpillar hairs. The infestation on the Cape appears to have declined from 1988 to 1989 and this insect is considered to be under control.

The Nantucket Pine Tip Moth threatens most pine species in the Northeast with the exception of white pine. Young stands of pine are most vulnerable to damage, with attacks resulting in a reduction in height growth, stem deformities, poor cone production and occasional tree mortality. Barnstable County has been most effected by this pest.

The Fall Web Worm is found in Middlesex County and does not cause severe damage because it feeds late in the season.

The Eastern Tent Caterpillar feeds on the foliage of various trees and leaves behind dirty, silken tents that ruin the appearance of ornamental trees. It feeds on wild cherry and apple and other ornamental fruit trees. Noticeably high populations of this insect were reported in Bristol, Norfolk, Middlesex and Berkshire Counties.

It is essential to remember that although insects and diseases affect the health of the forests, they are only

considered primary invaders. It is the secondary invaders such as shoestring root rot that actually kill the weakened tree. Repeated annual attack by one or more insects or disease, in combination or alone, weakens a tree to a point where the ever present shoestring root rot attacks the tree and kills it.

## **Trends**

Diseases are cyclical, either on an annual basis or in accordance with climatic conditions. Repeated infestations weaken trees and if they are unable to recover, mortality occurs. Control mechanisms, if available and economical, need to be applied when disease is first identified.

Most insects are also cyclical in nature and have building and receding population trends on a fairly consistent basis. Since they are cyclical, it is fairly easy to monitor the populations and predict when a population explosion will occur.

An example of this pattern of cycles is the Gypsy Moth. The last major outbreak of the Gypsy Moth occurred from 1979 to 1983 with the peak in 1981. Currently, the population is on the rise again. Given that this moth has an 8 to 10 year cycle, this indicates that during 1990 the population will increase and will explode in 1991. For some insects, such as the Pear Thrips, the cycle cannot be determined because the Commonwealth has not experienced the problem long enough to make predictions.

Trends in forest health as a result of air pollution are difficult to establish because of the relatively limited time over which this problem has been studied. It is assumed that decreases in ozone

exceedences will result in immediate reduction of stress from that source, but damage to plants can occur at ozone levels considerably less than those known to affect humans. Because the relationship between acid deposition and forest health is poorly understood it is difficult to say what improvements, if any, will be seen as acidic pollutants are reduced.

## **WILDLIFE AND BIOLOGICAL DIVERSITY**

Massachusetts records 54 land mammals (and 27 seals, whales and other marine mammals in coastal waters), 203 breeding birds (224 others recorded in migration or as non-breeders), 29 reptiles, 23 amphibians, and 82 fresh or brackish water fishes. Of these, 21 mammals, 41 birds, 2 amphibians, 1 reptile and 26 fishes are commonly hunted, trapped, or taken by fishing. The Massachusetts Division of Fisheries and Wildlife monitors harvests and user numbers through creel censuses, field check stations, tagging records, and mail and telephone surveys. Laboratory and field survey techniques include aerial and ground counts, singing surveys of breeding birds, radiotelemetry monitoring of marked animals, reproductive and age analyses of carcasses and scale samples, and population modelling. Among non-game species, 8 fishes, 8 amphibians, 14 reptiles, 30 birds, and 12 mammals are listed as "endangered", "threatened" or "special concern" and are closely monitored. Additionally, increased attention is being directed toward invertebrates, wild plants, and natural communities so as to direct maximum efforts toward conserving a diversity of flora and fauna.

## **Pollutants and Sources of Stress**

The single most serious threat to the wildlife of the Commonwealth is the loss of habitat. Adequate protection and management of the state's undeveloped land resources is essential to the conservation of fish, wildlife, and wild plants. This concept demands a holistic viewpoint focused on conserving biotic communities encompassing a multiplicity of species, rather than protection based solely on single-species management. Similarly, although significant advances have been made, other threats to wildlife persist. These include poisoning or reproductive inhibition by pesticides, heavy metals, PCBs, and acid precipitation; entanglement by or ingestion of plastic wastes; competition with introduced exotic wildlife or plants; loss or destruction of nest sites or other key habitat features; outbreaks of diseases or parasites; and public apathy and antipathy.

European settlers have had substantial influence on the fauna and flora of Massachusetts, commencing with Gosnold's temporary settlement on the Elizabeth Islands in 1602. Although Native Americans hunted and fished for food and hides and burned and cleared small patches for villages and agriculture, the entire Indian population of New England totalled only 25,000 in 1600. Europeans, backed by their more advanced technology, a capitalist economy intertwined with international trade networks, and an aggressive colonization and settlement scheme, rapidly altered the landscape of Massachusetts. Expanding inland from the coast and along river valleys, and then across wooded plateaus and rolling hills, Massachusetts' population reached 47,000 by 1692, 300,000 by the Revolution, and nearly 1 million by 1850.

Wildlife was drastically affected through this period, both by direct

exploitation for consumer products or for vermin control and, importantly, by destruction or alteration of habitats essential to the survival of wildlife.

These landscape changes caused some wildlife species to disappear from the state. Certain species became extinct, vanishing forever from the earth. The flightless great auk and the little-known Labrador duck, both winter visitors to the Massachusetts coast, faded away. The last known auks were killed in Iceland in 1844 and the last Labrador duck was shot in 1875 off Long Island, New York. The passenger pigeon, whose awesome multitudes thrilled Audubon, last bred in Massachusetts in 1889, with the last individual dying in the Cincinnati zoo in 1914. The Heath hen, an Atlantic coast variety of the prairie chicken found from Maine to Virginia, lost ground rapidly and was confined to Martha's Vineyard by the 1870s. The solitary surviving bird disappeared in 1931.

Other species disappeared from Massachusetts, but survived elsewhere. Elk disappeared by 1732, gray wolves by the 1820s, the cougar by 1858, and the pine marten by 1880. None of these has returned, although martens have been restored to northern New England. Sturgeon, once abundant in the Merrimack and other coastal rivers, almost vanished as rivers were dammed and polluted. In some instances, though, habitat replenishment, sound legal protection, and vigorous management have restored extirpated or nearly vanished species, including beaver, fisher, black bear, wood duck, Atlantic salmon, and bald eagle.

### Measures of Quality

By the 1980s, there had been

several outstanding successes in wildlife management, contradicting the dire predictions at the turn of the century. Beaver, largely absent since the late 1700s, flourished, with a population of several thousand across seven counties. The fisher, a large forest-dwelling weasel gone since the 1860s, reestablished itself in the 1970s and has attained a population of several hundred across central Massachusetts. Black bear, a rare straggler in the 1880s, numbered over 700 in western Massachusetts by 1988. White-tailed deer numbered only 5,000 in 1905 but, responding to conservative management schemes, reached 45,000 in 13 of 14 counties by the 1980s. Wild turkey disappeared by 1851, but were successfully reintroduced to the Berkshires in 1972 and reached a population of 8-10,000 in five counties by 1988.

Restoration programs involving Atlantic salmon, American shad, Plymouth redbelly turtle, bald eagle, and peregrine falcon have also shown success, with shad runs well established and salmon runs slowly growing in the Connecticut and Merrimack Rivers. Captive rearing programs for the redbelly turtle have "head-started" young turtles to avoid overwintering and predation loss and have bolstered the wild population of this endangered reptile. Peregrines nested in the state in 1987 for the first time since 1951 and bald eagles in 1989 for the first time since 1905. Rare plants and invertebrates are receiving increased attention and concern, after decades of neglect. Serious problems remain, however. Eight (10 percent) of 79 anadromous (migrating) and inland fishes, eight (35 percent) of 23 amphibians, 14 (48 percent) of 29 reptiles, 30 (14 percent) of 208 breeding birds, and 12 (14 percent) of 85 mammals (including marine species) are listed as

"Endangered," "Threatened," or "Special Concern."

## Trends

As can be seen from the foregoing, there are some encouraging signs of recovery and reintroduction of previously endangered and lost wildlife species in the Commonwealth. However, it would be inappropriate to conclude on the basis of these few success stories that all or most trends are positive. The loss of habitat, as described in those sections of this report dealing with open space and land use change, is clearly a negative trend in wildlife and biological diversity. The Commonwealth's success in maintaining healthy viable plant and animal communities depends to a very great extent on its success in protecting open space and directing development away from critical habitat.

*Publications and documents used as a basis for information presented in this chapter include the following:*

*"Ozone Air Quality Data Summary 1980 to 1988", Mass. Dept. of Environmental Quality Engineering, 1989. "Massachusetts Demonstration of Reasonable Further Progress - Ozone 1987", Mass. Dept. of Environmental Quality Engineering, 1988. "Massachusetts Demonstration of Reasonable Further Progress - Carbon Monoxide 1987", Mass. Dept. of Environmental Quality Engineering, 1988. "Commonwealth of Massachusetts Summary of Water Quality 1988", Mass. Dept. of Environmental Quality Engineering, 1988. "Acid Rain in Massachusetts", P. Godfrey, Univ. of Mass. Water Resources Research Center, 1988. "Massachusetts Marine*

*Fisheries - Assessment at Mid-Decade",  
Mass. Dept. of Fisheries, Wildlife and  
Environmental Law Enforcement, 1985.*

## CHAPTER V

### ACCOMPLISHMENTS TO DATE - TWENTY YEARS OF ENVIRONMENTAL PROTECTION EFFORTS IN MASSACHUSETTS

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In April of 1970 the United States first celebrated Earth Day, a clear signal to policy makers that the environment was about to take its place among other major public policy issues in the minds of the American people. Nearly 20 years later we have an opportunity to look back and assess our progress to date in protecting the environment, in addressing the legacies of past environmental ignorance and in securing a high quality environment for the future.

Over the past 20 years the federal government and the Commonwealth have put in place an array of environmental laws that, while many now require reauthorization and strengthening, have resulted in some important successes in protecting environmental quality. This Chapter considers some of the major environmental protection measures at the federal and state levels and some of the programmatic accomplishments resulting from these statutes. It concludes with a review of significant accomplishments and initiatives of the past 12 months.

#### **Environmental Efforts at the Federal Level**

On the first day of 1970 President Nixon signed into law the National Environmental Policy Act (NEPA), the purpose of which was to "encourage productive and enjoyable harmony between man and his environment." In addition to the national policy statements contained in NEPA, the Act also established the Council on Environmental Quality (CEQ), mandated the development of requirements for federal Environmental Impact

Statements (EIS) and required that CEQ issue an annual report on Environmental Quality in the US. That Act launched a decade in which virtually all the major federal statutes concerned with environmental protection were put in place. In 1970 alone Congress created the Environmental Protection Agency (EPA), passed significant amendments to the Clean Air Act which established the National Ambient Air Quality Standards and other key provisions and enacted the Resource Recovery Act for regulation and disposal of solid waste.

The federal Clean Water Act was created in 1972 through amendments that totally revised the Federal Water Pollution Control Act of 1948. This new Clean Water Act set out ambitious programs for the restoration and maintenance of the chemical, physical and biological integrity of the nation's waters. Its initial goal of zero discharge of pollutants by 1985 now appears overly optimistic, based on current experience. This Act also created the current classification for surface waters and set a then interim goal of achieving "fishable, swimmable" status wherever possible by mid-1983. Chapter 404 of the Clean Water Act is the federal basis for the protection of wetlands.

The Federal Environmental Pesticide Control Act was also passed in 1972. It was essentially a series of amendments to the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) of 1947 and redirected federal pesticide regulation away from specific concern for the agricultural community and more toward environmental and public health

concerns in general.

The Coastal Zone Management Act (CZMA) of 1972 recognized that "there is a national interest in the effective management, beneficial use, protection, and development of the coastal zone." This federal law encouraged coastal states to take advantage of federal funding to ensure protection and wise use of land and water in the coastal zone. The federal Office of Ocean and Coastal Resource Management is administered by the National Oceanic and Atmospheric Administration.

1972 also saw passage of the Ocean Dumping Act, the first two titles of the current Marine Protection, Research and Sanctuaries Act. The Ocean Dumping Act was intended to regulate intentional ocean dumping and to authorize related research. The third title of the Marine Protection, Research and Sanctuaries Act authorizes the establishment of marine sanctuaries.

The Safe Drinking Water Act was enacted in 1974. It required EPA to develop maximum contaminant levels (MCLs) for drinking water, regulations to protect groundwater resources, and grant programs for sole-source aquifer and wellhead protection. Initial interim regulations set MCLs for ten inorganic chemicals, six organic chemical pesticides, trihalomethanes, three radionuclides, microbes and turbidity. By 1986 only one of these 22 interim MCLs had been revised and no new standards for other contaminants had been promulgated. Congress consequently passed amendments which established the remaining 21 interim MCLs as primary regulations and set a three-year deadline for development of primary regulations for 83 specific contaminants.

The Resource Conservation and Recovery Act (RCRA) was enacted in 1976 as a substantial expansion and redirection of the Resource Recovery Act of 1970. RCRA authorized EPA to set standards for the regulation of facilities that generate or manage wastes and established a permit program for hazardous waste treatment, storage and disposal facilities. Amendments in 1984 added new requirements prohibiting land disposal of many types of hazardous waste as well as a new program for regulating underground storage tanks.

The federal Toxic Substances Control Act (TSCA), originally proposed in 1971, was signed into law in October of 1976. TSCA provided EPA with broad authority to test new and existing toxic chemicals and to control unreasonable risks and possible adverse effects to human health and the environment.

The last major piece of new federal environmental legislation to be enacted was the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980. CERCLA, often referred to as Superfund, authorized the federal government to respond to spills and releases of hazardous substances, to clean up hazardous waste sites, and established a dedicated fund for these purposes. CERCLA was expanded and renewed through the Superfund Amendments and Reauthorization Act (SARA) of 1986.

An examination of the major national environmental issues of 20 years ago suggests that, while in some areas we have done well, in other areas we have yet to decide how (or if) to move forward. In 1970 an entire chapter of the *First Annual Report of the Council on Environmental Quality* was devoted to

global climate change. Twenty years later we are still debating the predictions of global warming and whether it is reasonable to move forward in the face of scientific uncertainty. In 1970 acid rain had not yet been perceived as a serious problem. During the 1980s it loomed as one of the premier environmental issues of the decade and as a symbol of the perceived anti-environmentalism of the Reagan administration. As 1990 begins the nation has yet to act on this very serious problem about which there is little remaining uncertainty.

In 1978 hazardous waste broke into the headlines across the nation with the discovery of Love Canal in upstate New York. It was not that the federal government was unaware of the problem. While the public was focusing on the horrors of Love Canal the federal government was estimating that there were between 32 and 50 *thousand* hazardous waste disposal sites in the United States. CERCLA was passed in 1980 to address this issue. It has now been shown that the actual number, seriousness and cost of cleaning up these disposal sites was considerably under-estimated.

The greatest successes appear to be in national efforts to control conventional water pollutants and criteria air pollutants. Yet, compared with original goals, achievements in controlling water pollution have been only moderate and non-point pollutants appear to be on the increase as land use patterns result in problems that were unrecognized two decades ago. And, while significant progress has been realized in controlling air pollutants from stationary sources, pollutants from mobile sources continue to cause non-attainment for ozone and carbon monoxide in many areas.

## Environmental Protection Efforts in Massachusetts

Each of the national efforts to protect the environment has been reflected in the statutes and environmental programs of the Commonwealth and in most instances carried beyond what is required by the federal government. The Massachusetts Executive Office of Environmental Affairs (EOEA) was established (M.G.L. c. 21A) in 1974 when the Executive branch of the state was organized into a cabinet form of government. Chapter 21A placed within EOEA the Departments of Environmental Quality Engineering (now DEP); Environmental Management (DEM); Fisheries, Wildlife and Recreational Vehicles (now DFWELE); Food and Agriculture (DFA) and the Metropolitan District Commission (MDC). Three of these agencies (DEQE, DEM & DFWRV) were created by dissolving the Department of Natural Resources and combining its various programs and Divisions with programs from other state agencies (such as Public Health) and newly created programs.

The leadership of Governor Michael Dukakis and the Massachusetts legislature has been critical to establishing the Commonwealth's place at the forefront of the nation's efforts to protect the environment. Major new statutes that have resulted from the cooperation of the Executive and Legislative branches include the following:

The Public Waterfront Act (1983);  
The Interbasin Transfer Act (1983);  
The Open Space Bond Act (1983);  
The State Superfund Act (1983);  
The Massachusetts Water  
Resources Authority Act  
(1984);

The Acid Rain Control Act (1985);  
 The Water Management  
     Act (1985);  
 The Administrative  
     Penalties Act (1985);  
 The Wetlands and Wildlife  
     Protection Act (1986);  
 The Solid Waste  
     Disposal Act (1987);  
 The Open Space Bond Act (1987);  
 The State Revolving  
     Fund Act (1989);  
 The Cape Cod  
     Commission Act (1989);  
 The Toxic Use  
     Reduction Act (1989).

These laws span the entire field of environmental protection activity and provide a solid foundation for our future efforts.

Efforts to control pollution of both surface water and groundwater in the Commonwealth have moved in several positive directions during the past 20 years. The Massachusetts Clean Waters Act began to take its current form in 1966. In the early 1970s several substantive amendments were made to incorporate changes being made at the federal level, and in 1975 authority to implement the requirements of the various clean water statutes was transferred to DEQE, as was the case with many other environmental regulatory responsibilities. The Wetlands Protection Act of 1972 consolidated efforts to protect both coastal and freshwater wetlands; responsibility to carry out this Act was also passed to DEQE in 1975. A 1986 amendment to the Wetlands Protection Act added wildlife as an additional public interest to be protected. The Interbasin Transfer Act of 1983 and the Water Management Act of 1985 were both created to manage supplies of surface water and groundwater.

Air pollution control in Massachusetts also has a history that began in the mid 20th Century. Until DEQE's creation in 1975 the Air Pollution Control Act, which took its current form in 1970, was administered by the Department of Public Health. The success of this statute is well documented in the discussion of air quality in Chapter IV of this report. In 1985 the Acid Rain Control Act was enacted, mandating reduction in sulfur dioxide emissions from in-state sources by 30 percent of 1980 emission levels unless superseded by national legislation. As no federal acid rain control legislation had been forthcoming, regulations to achieve these reductions were promulgated in April of 1989.

Massachusetts programs to control hazardous wastes were initiated with passage of the Hazardous Waste Management Act of 1979. In 1980 the Hazardous Waste Facility Siting Act was enacted as the state corollary to RCRA and in 1983 the Massachusetts equivalent of the federal Superfund was created in the form of the Oil and Hazardous Material Release Prevention and Response Act. The passage of "Question 4" by public referendum in 1986 placed the identification, assessment and cleanup of hazardous sites in Massachusetts on a very ambitious schedule. The 1985 Administrative Penalties Act gave DEQE the right to assess civil administrative penalties for any violations of the statutes administered by the agency.

A comprehensive Coastal Zone Management Plan was adopted by the Commonwealth in 1978 and the Massachusetts Office of Coastal Zone Management was legislatively established in 1983. Protection of the marine waters and sea floor within state territorial waters

was furthered by the Ocean Sanctuaries Act of 1978, which required the Department of Environmental Management to establish regulations for the protection of five designated ocean sanctuaries. The Public Waterfront Act (M.G.L. c.91) was amended in 1983 to enhance public rights in tidelands, great ponds and rivers. The Coastal Facilities Improvement Act of 1983 established funds for the improvement of facilities that support various marine-related activities. Amendments to the Act in 1987 expanded the scope of the legislation to allow for the creation of a harbor planning program within the Office of Coastal Zone Management.

The creation of the Massachusetts Water Resources Authority in 1984 represented a major step forward in efforts to control coastal pollution and halt the further degradation of Boston Harbor. The Authority is currently carrying out an ambitious program to prevent future contamination and promote the eventual cleanup and restoration of Boston's ocean gateway.

Solid waste disposal in the Commonwealth is regulated primarily through the Solid Waste Disposal Act, last amended in 1987. The 1987 amendments authorized \$706.5 million to be spent on recycling, composting, landfill assessment and closure and new capacity development. Solid waste disposal was regulated by the Department of Public Health prior to 1975 and is currently regulated by the DEP Division of Solid Waste Management. The history of solid waste management has progressed through open air burning, landfilling, resource recovery, sanitary landfilling, incineration and recycling. The first major recycling effort came in the form of the Bottle Bill, which required three attempts before it was finally passed

through public referendum in 1982.

Efforts to protect open space within the Commonwealth have been numerous. The Open Space Bond Acts of 1983 and 1987 provided nearly three quarters of a billion dollars to acquire and protect the Commonwealth's land resources.

There are more than 45 separate programs administered by the Commonwealth's environmental agencies for the acquisition, protection and conservation of open space. EOEA was given the authority to create Areas of Critical Environmental Concern in 1974, the year it was established. The Agricultural Preservation Restriction Program within the Department of Food and Agriculture has resulted in the protection of over 25,000 acres of farm land since its enactment in 1977. In the past ten years some 32,972 acres of land have been acquired by the state's environmental agencies. DEP has assisted communities in protecting 697 acres under its Aquifer Land Acquisition Program. The EOEA Division of Conservation Services has protected many important parcels through the use of conservation restrictions and grants to cities and towns. DEM acquired more than 15,000 acres and as a result was able to create seven new state parks. Many other DEM programs such as the Bay Circuit, the Scenic Rivers Program, the Heritage State Parks and the Connecticut River Valley Action Program have added immeasurably to the natural and cultural resource heritage that we shall pass to future generations.

The Massachusetts Pesticide Control Act of 1978 placed responsibility for the regulation of pesticides in the Department of Food and Agriculture. DFA has recognized the potential problems of pesticide use in a rapidly developing

landscape and has implemented several excellent research, development and regulatory programs. Integrated Pest Management techniques have been developed by the University of Massachusetts for several major crops in the Commonwealth including apples, cranberries and sweet corn. Regulations have been established for the use of herbicides on public rights-of-way, lawn chemicals and aerial applications.

### **Accomplishments Within the Past Year**

During 1989 several important pieces of legislation were enacted that will result in some important new environmental protection tools. The Toxics Use Reduction Act sets a statewide goal of reducing toxic waste generation by 50 percent by the year 1997 through reduction in the use of toxic materials, and provides for research and development, and technical assistance in assisting companies to reach this reduction goal.

In December 1989, passage of the Cape Cod Commission Act allowed for Cape Cod as a region to begin to address land use issues and projects of regional concern.

The State Revolving Fund Act will result in billions of dollars of state monies being made available at below-market rates to water and sewer districts for construction and updating of badly needed infrastructure.

New policies were promulgated in some important areas. The acid rain regulations required by the Acid Rain Control Act of 1985 were put in place. Reid Vapor Pressure regulations were established to lower the volatility of gasoline sold in the Commonwealth. Stage

II vapor recovery regulations were promulgated to prevent the evaporation of VOCs during refueling of automobiles. Regulations requiring the degradability of plastic six-pack rings and protecting the endangered Right Whales were released.

A record \$80 million was spent for the acquisition and protection of open space. The Department of Food and Agriculture passed the half-way mark in its goal to protect 50,000 acres of farmland through its APR program by 1993. An ambitious new Land Protection Agenda was established within the environmental agencies and a forward looking Rivers Policy was released by EOEa.

Ground was broken for the Springfield Material Recycling Facility which, at 240 tons per day, is the nation's largest recycling facility, serving 85 communities and over 700,000 people. DEP also developed new regulations to govern the siting and operation of solid waste disposal facilities.

Important new efforts to provide more effective administration of the Commonwealth's environmental programs followed in the wake of the Report of the Special Commission on Environmental Operations in February of 1989. EOEa has improved its management of policy development and implementation throughout the Secretariat. DEQE moved forward with a reorganization plan and legislation changed its name to the Department of Environmental Protection. EOEa continues to move forward with an aggressive program to computerize its data collection and management efforts. EOEa also put into operation MassGIS, its environmental geographic information system during the past year. The legislature passed a law turning over the uncollected deposits on bottles and cans

to the Commonwealth.

A new and aggressive Enforcement Policy was announced and the creation of an Environmental Crime Strike Force, a DEP Office of Enforcement and put some real teeth into the effort. As a result DEP's Enforcement Office imposed a record number of Administrative Penalties including the largest in the history of the Commonwealth for violation of the Wetlands Protection Act, asbestos pollution and solid waste disposal regulations. The Department of Fish, Wildlife and Environmental Law Enforcement's Operation Berkshire resulted in the apprehension of a ring of poachers who were killing bears in Western Massachusetts.

EOEA initiated efforts to develop public and private partnerships in the protection of environmental quality, open space and recreational opportunities. The ENVest program welcomed private contributions to such programs as MASS RELEAF, an effort to plant shade and forest trees, and partnership programs in which companies were encouraged to contribute to the upkeep of nearby state parks, beaches and other facilities.

## CHAPTER VI

### WORKING TOWARD A BETTER ENVIRONMENT

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Earlier chapters of this report have been devoted to explanation, measurement, and history. In this chapter, we turn to policy declaration and agenda setting.

Setting environmental goals is both necessary and risky. Necessary, because achieving any great purpose requires vision and planning. Risky, because the potential exists for plans to appear hopelessly out of date in a very short time. If a document such as this had been prepared a mere dozen years ago it would likely have been silent on the subject of hazardous waste sites, a problem that now consumes considerable staff and financial resources not only in Massachusetts but across the entire nation. An agenda set just five years ago would not have had the same urgency about the problem of CFCs because the holes in the earth's ozone layer had not yet been discovered. We can only hope that undiscovered problems of this magnitude do not soon emerge to menace our environment and bedevil our planning.

The years ahead must be dedicated both to preventing future harms and to striving to make our environment better, not merely fighting to stand still. This will be no easy task. It will require government to re-examine how it manages environmental protection. It will require citizens to better understand their cumulative effects on natural resources and take action to minimize them. It will require industry to consistently innovate to avoid adverse impacts and achieve safe solutions. We will need to move away from single-medium and point source-based views of the world. We must begin to recognize and deal with more subtle

environmental issues: the effect one control technology has on other resources; the ability of industrial processes to re-use as a resource what was once discarded as waste; consumer acceptance of products that have been altered to conform with good environmental practices; and incorporation of an environmental ethic into all of our daily lives.

What we present in this Chapter, then, is a working document. For each major policy area it sets forth where we would like to be and what we would like to achieve over the next year and the next five years. It is not intended to be an exhaustive compilation of Environmental Affairs activities and objectives during these periods, although it does include most major initiatives and goals. It is intended to be a working document, one that state officials and citizens will review periodically to see if sufficient progress is being made and to consider whether our goals were appropriate, realistic, and sufficiently ambitious. It is also our intention that this agenda-setting, like the State of the Environment report as a whole, be an annual exercise, and that the one- and five-year plans contained herein be updated each year.

#### AIR

Massachusetts has been in the vanguard of states in acting to protect our most pervasive resource. We must continue to be so in the years ahead. But because air quality, more than that of any other resource, is subject to forces beyond our borders, we will also need national and international action to ensure adequate

protection.

By the end of 1994, Massachusetts should:

- \* reduce its own sulfur dioxide emissions by more than 30 percent (compared with 1980 levels) and reduce nitrogen dioxide emissions by 4-5 million tons per year;
- \* work in concert with other states and the federal government to halt the increasing acidification of lakes, ponds, and streams and the damage to forests caused by acid deposition;
- \* attain compliance with the National Ambient Air Quality Standard (NAAQS) for ozone and carbon monoxide, while remaining in compliance with standards for other criteria pollutants;
- \* set and enforce standards for key toxic air pollutants as part of an integrated cross-media strategy of pollution prevention;
- \* ban the production and use of harmful chlorofluorocarbons (CFCs) which are the major cause of upper-level atmospheric ozone depletion and appear to be a major contributor to global warming;
- \* improve plans and implementation of measures to discourage unnecessary automobile traffic, especially in and around our metropolitan areas; and
- \* replace the state's automotive fleet with more fuel efficient cars and trucks and vehicles that operate on cleaner fuels.

During 1990, Massachusetts should:

- \* continue to forcefully advocate a stronger federal Clean Air Act, including a national plan to reduce acid rain precursors;
- \* work with its congressional delegation on national legislation requiring or providing stronger incentives for the production of more fuel efficient cars;
- \* discourage unnecessary automobile traffic by enforcing parking restrictions currently in effect in Cambridge, Boston and East Boston, expand the restricted area in East Boston and place new restrictions on parking in South Boston, and encourage use of mass transit through reviews of proposed fare increases and otherwise;
- \* continue to carefully review all proposals for major new facilities that may cause or contribute to air pollution;
- \* enact legislation agreed to with other NESCAUM states to require automobiles sold in Massachusetts to meet the current California auto emissions standards, and promulgate regulations to do so prior to legislative enactment;
- \* enact "greenhouse" legislation to significantly reduce the amount of carbon dioxide being released into the atmosphere by providing incentives for fuel efficiency to developers of large projects, requiring state buildings to install fuel-efficient lighting systems, and restructuring the existing sales tax

on automobiles to a sliding scale to promote the use of fuel-efficient automobiles; and

- \* wherever possible, encourage non-polluting alternatives such as energy conservation, waste prevention and recycling rather than the construction and permitting of new polluting facilities.

## **WATER**

Like its neighboring states, Massachusetts has abundant water resources. These surface and underground sources of water had and continue to have a profound effect on our economic development, our settlement patterns and on our quality of life. We have in many ways come to take for granted an adequate supply of high quality water for personal, agricultural, recreational and industrial purposes.

The danger to the quality and abundance of our water supplies lies in our own activities, which can lead to contamination and over-use of our resources and disrupt both the man-made and natural systems that require it. We must strive to make our use of water resources consistent with sustaining long-term quality and availability.

By the end of 1994, Massachusetts should:

- \* achieve a 10 percent improvement in water quality (compared with 1989 levels) in water bodies not currently supporting their designated classification through source reduction, construction and improvement of wastewater

treatment plants, and the control of non-point pollution;

- \* achieve a savings of 5 percent of public water supplies in non-MWRA communities through such conservation measures as leak detection, system rehabilitation and water-saving equipment and devices;

- \* complete plans for 25 of the state's 28 river basins and issue water withdrawal permits in accordance with those plans;

- \* with other states, convince the federal government to resume its historical role of providing substantial funding for water pollution control, a role it has largely abandoned;

- \* make approximately \$1.8-2 billion in loan commitments to municipalities and regional water and sewer districts from the State Revolving Fund created by the SRF Act of 1989; and

- \* complete the state-wide Assessment of river basins called for in EOEA's 1989 Rivers Policy.

During 1990, Massachusetts should:

- \* complete and implement new stronger water quality standards;

- \* update and revise the state's water policies to place greater emphasis on protection of and planning for water resources and to recognize multiple uses of water;

- \* enact watershed protection legislation to prevent development

in sensitive areas near drinking water supplies;

- \* implement the key recommendations of the state's non-point source action plan, including completing the Best Management Practices Manual and continuing ongoing initiatives in the Merrimack and Westport river basins;

- \* complete three new river basin plans and issue permits for water withdrawals in accordance with those plans; and

- \* continue to enforce anti-pollution laws with a focus on watershed protection.

## LAND AND GROWTH

Massachusetts has experienced substantial economic growth during the 1980s. It is not this growth in and of itself that poses a danger to our environment, but unplanned growth, growth that does not respect environmental limits, and growth that occurs before construction of the infrastructure that can mitigate its impacts.

The challenge in the coming years is to anticipate the problems of growth and to prevent them so that we may all share in the benefits of a vibrant economy and avoid the huge costs of environmental cleanup. In this way we can ensure that the growth that takes place in Massachusetts is **sustainable** and enhances rather than degrades our environment and our way of life.

By the end of 1994, Massachusetts should:

- \* halt the loss of wetlands that threatens to eliminate wildlife habitat, causes water contamination and flooding problems, and changes the character of the Commonwealth's landscape;

- \* protect 132,000 acres of wetlands through the Wetlands Restriction Program;

- \* enact state-wide land use planning and management legislation;

- \* prepare and execute a half-decade plan for the coordinated acquisition of open space by all environmental agencies that results in the full use of current bond spending authority;

- \* enact new authority in the amount of \$750 million (1990 dollars) to issue bonds for future open space acquisitions;

- \* protect 50,000 acres of prime farmland through agricultural preservation restrictions (APRs), bequests, and other measures; and

- \* explore the applicability and usefulness of regional entities such as the Cape Cod Commission for the protection of other regions of the Commonwealth and encourage regions wishing to avail themselves of such an entity.

During 1990, Massachusetts should:

- \* enact legislation allowing on-site inspections by state and local officials of suspected wetlands violations;

\* assist with the implementation of the Cape Cod Commission Act;

\* work with its congressional delegation and with other states to enact the American Heritage Trust Act which would establish a self-perpetuating trust for land acquisition;

\* move toward no net loss of wetlands, endangered species habitat, or other critical resource areas unless no possible alternatives exist;

\* move toward no loss of state or local park or conservation lands unless no feasible alternatives exist and only then when land is substituted in its place or clear public benefit results;

\* begin to manage state lands to emphasize the protection of their ecological function and sustain their value for the future;

\* enact legislation to reform the Massachusetts Environmental Policy Act (MEPA) to allow local boards to refer cases for MEPA review, to allow citizens legal standing to challenge MEPA determinations, to prohibit construction until MEPA review is complete, and to authorize penalties for violations of MEPA and its regulations;

\* enact legislation that revises the current "grandfathering" provisions for subdivision plans (M.G.L. c.40A sec. 6) to maintain protection only for projects being actively implemented;

\* develop a state program for Conservation Restrictions (CRs) and expand their use on both public and private lands; and

\* strengthen the inland Areas of Critical Environmental Concern (ACEC) Program and encourage local groups to nominate areas for the protections afforded by inclusion; adopt 3 to 6 inland ACECs.

## SOLID WASTE

Public awareness of the problems of solid waste disposal has never been higher. Concerns have risen around the Commonwealth with the volume of waste we generate, the dangers it poses to our air (when we burn it), our water and land (when we bury it), and the drain it imposes on our fiscal resources (whatever we do with it).

There is no quick fix for the problem of what to do with our trash. Our best course of action is to put integrated solid waste management into practice, to recognize that there are better and worse ways of dealing with trash. It is generally better to burn trash than to bury it, better still to recycle and reuse materials before discarding them, and best of all not to generate unnecessary waste in the first place, especially waste with toxic or hazardous components. Putting these principles into effect as economically as possible (and removing impediments to achieving them) while protecting public health and safety will be our task for the future.

By the end of 1994, Massachusetts should:

- \* ban leaf and yard waste, automobile batteries, tires, white goods and most recyclable trash from landfills and incinerators;

- \* achieve 100 percent leaf and yard waste composting in every city and town in the Commonwealth;

- \* expand recycling of paper, glass, aluminum, ferrous metals and plastics to 60 percent of the households in the state;

- \* achieve a rate of 40 percent state procurement of recycled paper products;

- \* close all 166 landfills in the Commonwealth that do not have liners; and

- \* reduce the amount of solid waste Massachusetts generates by 4 percent.

During 1990, Massachusetts should:

- \* issue new, state-of-the-art regulations to limit further the risks posed by solid waste disposal facilities;

- \* allow no new landfills that do not fit within the regional needs identified in the Solid Waste Master Plan, have double liners for groundwater protection, and serve a regional population;

- \* expand leaf and yard waste composting to include 185 communities (115 are already taking part);

- \* work with the 85 cities and towns in western Massachusetts to achieve a 25 percent recycling rate at the Springfield Material Recovery Facility;

- \* continue to work with municipalities and regional groups around the Commonwealth to site and develop privately owned and operated Material Recycling Facilities (MRFs), including the facilitation of tax-exempt financing;

- \* continue efforts to develop new markets for glass, paper, metal and plastic recycled material in cooperation with potential industrial and commercial users;

- \* expand the recycled product procurement program to aluminum signs for highways, to composted soil supplements for park and highway maintenance, and other innovative opportunities;

- \* work with both the federal government and regional organizations (Coalition of Northeastern Governors and Northeast Recycling Council) to provide better consumer information regarding the environmental "friendliness" of products and packaging;

- \* enact a state labelling law that better enables citizens to make environmentally sound purchasing decisions; and

- \* enact new restrictions on, or disincentives for, unnecessary packaging materials.

## TOXIC AND HAZARDOUS MATERIALS AND WASTES

Today's toxics problem is an unintended by-product of a quantum change in how we make things and generate energy. Just as the Industrial Revolution of the 19th Century substituted machines for human labor, the Chemical Revolution of the 20th Century substituted thousands of new compounds for a relative few that had sufficed before. In both cases, stunning productivity gains resulted. But just as industrialization led to social upheaval and worker alienation, we have come to recognize that this century's chemical breakthroughs have had their costs as well. They have brought about widespread contamination of resources, threatened the operation of natural systems and the survival of species, and endangered humans to a degree we may not fully know for years. Modern living may indeed be hazardous to our health.

In the years ahead, Massachusetts must both address the damage done in the past, most notably the thousands of contaminated sites, and prevent more damage from occurring. We can also encourage technological innovations in the hope that they will lead to safer substitute materials and new remediation measures. Most important, we must take all available steps to reduce and minimize our use of toxic and hazardous materials.

By the end of 1994, Massachusetts should:

- \* reduce its use of toxics by 35-40 percent through implementation of the Toxics Use Reduction Act of 1989, which set a goal of 50 percent reduction by 1997;

- \* provide for its remaining future need to dispose of hazardous and low-level radioactive wastes through a combination of agreements with other states and siting of safe in-state facilities, as required under federal law;

- \* have in full operation a system of cross-media regulation and tracking of potential contaminants, including a complete database and on-line information capability; and

- \* increase the rate of discovery, assessment, and cleanup of hazardous waste sites.

During 1990, Massachusetts should:

- \* complete its survey of Massachusetts toxics users;

- \* establish the new Toxics Use Reduction Institute, Council on Toxics Use Reduction, Toxics Use Advisory Council and Office of Technical Assistance called for in the 1989 Toxics Use Reduction Act;

- \* continue to review proposals to site facilities for the treatment, storage and disposal of hazardous wastes so as to provide all necessary protections for public health, safety and the environment;

- \* respond to and ensure the containment of an expected 5,500 reported spills of oil and hazardous materials;

- \* complete the comprehensive assessment of 65 suspected hazardous waste sites, the cleanup

of 19, and provide for the assessment and cleanup of 340 sites through the DEP waiver process;

- \* fully recover the costs of overseeing waste site cleanups from responsible parties wherever possible;

- \* enact a pesticides reform statute that would place responsibility for determining which chemicals are safe in the hands of an expert Hazards Review Committee and provide greater protection for critical environmental areas;

- \* continue to promote agricultural chemical reduction efforts through biological control, integrated pest management and low-input sustainable agricultural research; and

- \* institute criminal proceedings against intentional emitters and dumpers of hazardous materials in violation of laws, regulations or permits.

## COASTAL RESOURCES

The Commonwealth's history and way of life has been heavily influenced by its coast. From the first European settlers at Plimoth to the Revolution's beginnings in Boston ("one if by land, two if by sea"), from the shipwrights and fishermen of Salem, Gloucester and New Bedford to the villagers of Cape Cod and the Islands welcoming the annual return of visitors, our state and people have been shaped by the sea.

For most of human history, people believed that the ocean was so vast that

we could not do it harm, that whatever we put into it would quickly dilute and be rendered harmless, and whatever we took out of it would replenish itself. We have learned, and are continuing to learn, that this is not so. We are also witnessing the harmful effects of overdevelopment of the coast and the special places that have been so important in our past and remain so in our present. The future of the coast and the ocean itself will depend largely on the choices we make in allowing further development, energy exploration and waste disposal, and in managing marine resources.

By the end of 1994, Massachusetts should:

- \* implement the recommendations of the Buzzards Bay Comprehensive Conservation and Management Plan;

- \* have secured an additional 50 miles of coastline for public use through acquisition, conditioning of development projects, bequest, or other measures;

- \* have approved several Harbor Management Plans from communities wishing to plan for the future of their waterfronts;

- \* have met all interim milestones in the Boston Harbor cleanup project;

- \* have gained a fuller understanding of the consequences for the Commonwealth of predicted sea-level rise and taken steps to discourage or prohibit inappropriate coastal construction; and

- \* enact legislation that provides funds for the acquisition of storm-damaged property.

During 1990, Massachusetts should:

- \* hold regional hearings and revise its existing coastal policies;
- \* adopt comprehensive regulatory changes under the state's Public Waterfront Act (M.G.L. c.91) to ensure the public's rights in tidelands, great ponds and rivers;
- \* promulgate new Harbor Planning regulations;
- \* develop a program to provide better public access to coastal areas;
- \* continue to work with coastal communities on the designation and management of coastal ACECs;
- \* continue to vigorously assert consistency review jurisdiction under the federal Coastal Zone Management Act over activities that affect the Massachusetts Coastal Zone; and
- \* continue to oppose, with the state's congressional delegation, any leasing of offshore areas for oil and gas exploration and drilling that would be inconsistent with state policies and objectives.

## FISHERIES AND WILDLIFE

As much of this report points out, it is often difficult for humans to deal with the environmental problems their activities create. For the animals, birds, and fish that

share our environment, the problems are even greater. Millions of years of evolutionary development have not provided them with defenses against chemical contamination, destruction of habitat, and other threats posed by human activity. Mistakes made in our stewardship of the environment can have severe consequences, including the endangerment and even the extinction of species.

As we seek to make Massachusetts more livable for people, we need to keep in mind the other living things around us. Some of them - our fisheries resources are a prime example - are important to us economically. All of them are deserving of protection and respect in their own right. Their fate is in our hands.

By the end of 1994, Massachusetts should:

- \* develop an atlas of established habitat of all state-listed species, using Geographic Information System technology now resident at EOEA;
- \* develop the expertise necessary to improve the measurement of damage caused by toxic contamination of fish and wildlife habitat;
- \* restore at least one half of the 95,642 acres of shellfish beds that are currently closed due to contamination;
- \* continue to make progress on updating sanitary surveys of shellfish areas, reaching an additional 25 percent of areas beyond the 38 percent completed at the end of 1989;

- \* protect riparian habitat by acquiring an additional 100 miles of river front and stream bank;

- \* manage its fisheries resources to ensure a sustainable yield and prevent overfishing; and

- \* encourage the development of an environmentally-sound aquaculture industry.

During 1990, Massachusetts should:

- \* enact the Endangered Species Protection legislation that would both make it illegal to destroy or "take" an endangered species and provide the first meaningful habitat protection for state-listed species;

- \* enforce the law requiring plastic six-pack rings sold in the Commonwealth to be bio- or photo-degradable;

- \* certify 100 additional vernal pools for protection under the Wetlands Protection Act;

- \* develop a methodology for determining the minimum stream flow regime required to sustain a healthy fishery; and

- \* extend the "catch and release" management policy to enhance protection of native trout streams.

## RECREATION

Leisure and recreational opportunity are very important to the Commonwealth's citizens. Our natural environment and our recreational facilities have exhilarated,

challenged, educated and inspired generations. We would be a lesser state and a lesser people without them.

In tight fiscal times, our recreational assets and programs are among the most vulnerable. For the foreseeable future, we are unlikely to be able to add to these assets and programs at the rate we would like. But we must strive to prevent retreating from our historical commitment to recreation. This will require us to continue managing our recreational programs as carefully as possible to get the most out of every dollar.

By the end of 1994, Massachusetts should:

- \* complete the next Statewide Comprehensive Outdoor Recreation Plan (SCORP);

- \* improve awareness of recreational opportunities among all of the Commonwealth's residents;

- \* create linkages between urban and rural recreational opportunities and facilities;

- \* adopt and implement a plan for capital maintenance at state recreational facilities;

- \* develop, secure funding for and implement a program for the cleanup of hazardous waste and other illegally dumped debris on state recreational lands;

- \* develop, coordinate and promote a state-wide trails program including canoe and bicycle trail systems; and

- \* adopt a plan and lay the groundwork for the Commonwealth to be home to a truly "world class" zoo at Franklin Park by the end of the decade, building on the foundation of the recently-opened Tropical Forest Pavilion.

During 1990, Massachusetts should:

- \* take advantage of all possible opportunities to raise and dedicate revenues for its recreational programs, consistent with the goal of making access to these programs available to all residents;

- \* aggressively enforce the law against those who would use temporarily-closed recreational facilities for dumping grounds or other unlawful purposes;

- \* continue to provide first-rate recreational services at all open facilities; and

- \* make use of volunteers of all ages to help provide programs, develop projects and maintain recreational facilities.





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